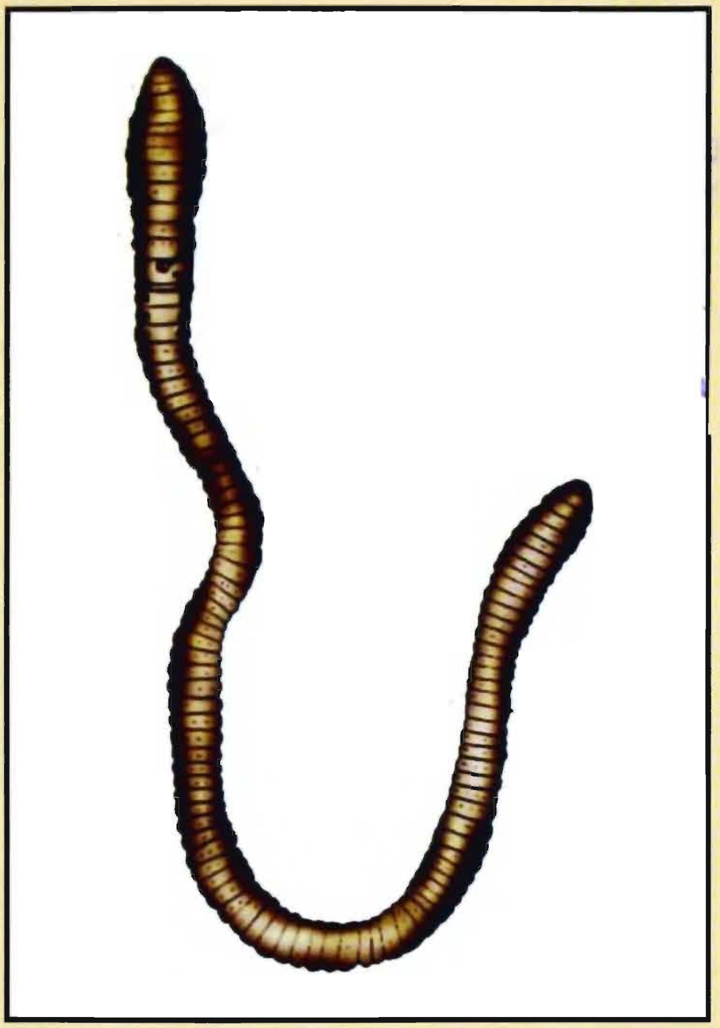
OCCASIONAL PAPER No. 324

On Taxonomy and Ecology of Earthworms (Annelida : Oligochaeta)

from Uncultivated and Waste Disposal Sites of West Bengal with some notes on their Microbial Association

A. CHOWDHURY, A.K. HAZRA & A.P. NANDI



ZOOLOGICAL SURVEY OF INDIA

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RECORDS OF THE ZOOLOGICAL SURVEY OF INDIA

On Taxonomy and Ecology of Earthworms (Annelida : Oligochaeta) from Uncultivated and Waste Disposal Sites of West Bengal with some notes on their Microbial Association

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RECORDS
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INTRODUCTION

Systematic studies of earthworms of the Indian subcontinent were initiated by Templeton (1844). There after a series of workers have published on earthworm taxonomy *viz.* Perrier (1872), Beddard (1883, 1895, 1900, 1901, 1902), Michaelsen (1900, 1909a, b, 1913), Stephenson (1913, 1916, 1917, 1920, 1922a, b, 1923, 1930), Gates' (1937a, b, 1938a, b, 1972), Tembe and Dubash (1961), Halder and Julka (1967), Soota and Julka (1970, 1972), Julka (1975a, b, 1976a, b, 1977, 1978, 1979, 1981a, b, 1983, 1988, 1993a, b, c, 1995, 2001, 2005), Julka and Halder (1975a, b, 1977), Soota and Halder (1977a, b, 1980a, b, 1981), Kale and Krishnamoorthy (1978), Julka and Rao (1982), Ismail and Murthy (1985), Ismail (1986), Julka and Chandra (1986), Julka and Senapati (1987), Julka and Paliwal (1989b, 1993, 1994), Julka *et al.* (1989), Bano and Kale (1991), Julka *et al.* (1997), Blanchart and Julka (1997), Halder (1998, 1999, 2000), Patnaik *et al.* (2004), Tripathi and Bhardwaj (2004), Chowdhury and Hazra (2009).

Charles Darwin (1881) perhaps first discovered the relationship between earthworm and soil fertility. There after several workers have studied on ecology of earthworm fauna as well as microbial communities in soil of different ecological sites in India and abroad *viz.* Bassalik (1913), Stöckli (1928), Evans (1948a, b), Hopp and Slater (1948, 1949), Joshi and Kelkar (1952), Roy (1957), Khambata and Bhatt (1957), Satchell (1958, 1960, 1980, 1983a), Gates (1961), Parle (1963a, b), Dash and Cragg (1972), Huntjens (1972), Dash *et al.* (1974, 1979), Alexander (1977), Dash and Patra (1977, 1979), Laudelout *et al.* (1978), Rahno *et al.* (1978), Senapati *et al.* (1979, 1999, 2002), Verma and Chauhan (1979), Chauhan (1980), Dash and Senapati (1980, 1981, 1982, 1986), Behera and Dash (1981), Kale and Krishnamoorthy (1981, 1982), Kaleemurrahman and Ismail (1981), Senapati and Dash (1981, 1983, 1984, 1991), Ghabbour and Shakir (1982), Choudhuri and Mitra (1983), Julka *et al.* (1983), Lee (1983, 1985, 1987), Julka and Mukherjee (1984), Mishra and Dash (1984), Sahu and Senapati (1986, 1991), Christensen (1987, 1991), Huhta and Kulmala (1987), Scheu (1987), Edwards and Fletcher (1988), Krishnamoorthy and Ramachandra (1988), Sahu *et al.* (1988), Bhadauria and Ramakrishnan (1989), Julka and Paliwal (1989a), Tiwari *et al.* (1989, 1992), Hazra and Choudhuri (1990), Ismail *et al.* (1990), Senapati and Sahu (1991, 1993), Darlong and Alfred (1991), Marinissen (1991), Daniel and Anderson (1992), Kristufek *et al.* (1992), Pal *et al.* (1992), Bhadauria *et al.* (1997), Lavelle *et al.* (1998, 2000, 2003), Brown *et al.* (1999), Senapati (1999), Haynes *et al.* (2003), Hubers *et al.* (2003), Shuster *et al.* (2003), Kale and Dinesh (2005), Chowdhury *et al.* (2007).

Several authors have studied the impact of heavy metals on earthworm fauna and soil microflora *viz.* Gish and Christensen (1973), Van Hook (1974), Van Rhee (1975, 1977), Ireland (1975a, b, 1979, 1983), Ireland and Wooton (1976), Ireland and Richards (1977), Anderson (1979, 1980), Carter *et al.* (1980, 1983), Curry and Cotton (1980), Hartenstein *et al.* (1980), Ma (1982), Malecki *et al.* (1982), Morgan and Morgan (1999), Hazra and Bhattacharyya (2003), Homa *et al.* (2003), Nahmani *et al.* (2003), Chowdhury and Hazra (2007).

The review of literature revealed that in India the research work on these fields either lacking or fragmentary. No consolidated work has been carried out on taxonomy, ecology, impact of heavy metals and soil microorganisms in respect to earthworm. Therefore to fill up these lacunae the authors made the present investigation in order to have more or less comprehensive picture on soil bacteria, actinomycetes, fungi, and earthworm in relation to different biotic and abiotic factors and polluting agents like heavy metal contaminated soil. In this context the present investigation has been conducted in three different habitats of West Bengal with the following objectives:

1. To study the taxonomy, diversity, seasonal abundance and population fluctuation of earthworm fauna in three different ecological sites.
2. To ascertain the quantitative and qualitative composition and population fluctuation of fungi and bacteria-actinomycetes communities of these sites.
3. To evaluate the soil factors like temperature, relative humidity, pH, electrical conductivity, organic Carbon, Nitrate, Phosphate, Potassium and their impact on the population and distribution pattern of earthworm fauna as well as on soil microorganisms.
4. To analyze the heavy metal pollution (*viz.* Cadmium, Zinc, Lead and Copper) on soil and its effects on earthworm and microbial population.
5. To correlate these edaphic factors on the fluctuation of population of earthworm and microorganisms by statistical means.

MATERIALS AND METHODS

Collection, narcotisation and preservation of earthworm samples were carried out following Julka (1988). Collection, preparation and analysis of soil samples was done by adopting the standard methodology as described in Basak (2000). Mechanical analysis of soil has been done by Hydrometer method (Piper, 1942). Soil thermometer was used to record the temperature of the soil. Soil relative humidity was measured by dial hygrometer (HUGER - 85 mm – MODEL - 8265). pH of the soil was determined in water by the electronic pH meter Model No. 335 — Systronics). Electrical conductivity of the soil was determined by direct reading conductivity meter (Model No. 304 — Systronics, conductivity cell type C. D-10). Analysis of soil Zn, Cd, Pb and Cu was done after acid (Nitric and Perchloric) digestion by using a Varian Techtron AA – 575 atomic absorption spectrophotometer in R.S.I.C, Bose Institute, Kolkata. Cultivation and isolation of microorganisms has been done as per Kanwar *et al.* (1997). Identification of fungi has been made as per Alexopoulos *et al.* (1996) and bacteria-actinomycetes genera have identified by series of biochemical tests as per Kanwar *et al.* (1997) and Bergey's Manual of Determinative Bacteriology (Holt *et al.*, 2000).

OBSERVATIONS

TAXONOMY

Earthworm samples collected randomly from three different habitats *viz.* Municipal wastes disposal site at Dhapa, Kolkata (DP); uncultivated field site at Madhyamgram, North 24 Pgs. District (MD) and Bethuadahari Reserve Forest, Nadia District (BRF) for taxonomic study.

A key to the identification of earthworms of studied agroecosystems and waste disposal site in West Bengal

1. Male pores in intersegmental furrow 10/11 .... 2. (Family : Moniligastridae).
— Male pores behind segment xvi. .... 3.

2. Male pores superficial in a semicircular arch .... *Drawida papillifer papillifer.*
— Male pores distinct on markedly protuberant porophores ..... *Drawida nepalensis.*

3. Setae 4 pairs on each segment; prostate tubular .... 4. (Family : Octochaetidae).
— Setae numerous on each segment; prostate racemose. .... 8 (Family : Megascolecidae).

4. Male and prostatic pores on segment xvii; seminal grooves absent .... 5.
— Male pores on segment xviii; prostatic pores at the end of seminal grooves on segments xvii and xix .... 7.

5. Male pores discharge directly on body surface on low circular porophores (avestibulate), penes absent .... *Eutyphoeus incommodus.*
— Male pores discharge into deep paired copulatory pouches (vestibulate), each pore on posterior wall of an annular to elongate pene .... 6.

6. Spermatheal pores at *ab*; penes elongate and tubular .... *Eutyphoeus nicholsoni.*
— Spermathecal pores at *bc*; penes annular .... *Eutyphoeus orientalis.*

7. Spermathecal pores median to *a* line, close to midventral line; no setae on segments viii and ix copulatory; seminal grooves at or median to *a* line. .... *Octochaetona beatrix.*

— Spermathecal pores minute, at *ab*, setae *a*, *b* on segments viii and ix copulatory and surrounded by well developed tumescences; seminal grooves at or median to *b* line. .... *Octochaetona surensis.*

8. First dorsal pore at or anterior to intersegmental furrow 5/6 .... 9.

— First dorsal pore at or posterior to intersegmental furrow 9/10. .... 10.

9. Male pores on slightly raised circular to oval areas, penes absent; penial setae present. .... *Perionyx excavatus.*

— Male pores at the base of elongate and medially grooved penes arising from center of a cushion like large porophores; penial setae absent. .... *Perionyx simlaensis.*

10. Clitellum on segments xiii-xvii; female pores paired; penial setae present. .... *Lampito mauritii.*

— Clitellum on segments xiv-xvi; female pore single; penial setae absent. .... 11.

11. Male pores discharging directly onto body surface. .... *Amynthus corticis.*

— Male pores discharging into copulatory pouches opening onto body surface through secondary male pores. .... 12.

12. External genital markings absent; spermathecal pores 3 pairs at intersegmental furrows 6/7/8/9 .... *Metaphire houlleti.*

— External genital markings present; spermathecal pores otherwise. .... 13.

13. Spermathecal pores in paired groups of 2-5, at intersegmental furrows 5/6/7 or absent; openings of male copulatory pouches longitudinal; cresentic genital markings usually in some or all of segments xix-xxiv. ..... *Polypheretima elongata.*

— Spermathecal pores 4 paired, at intersegmental furrows 5/6-8/9; opening of male copulatory pouches circular; genital markings usually on segments xvii and xix. .... *Metaphire posthuma.*

SYSTEMATIC ACCOUNT

Class **Oligochaeta**

Order MONILIGASTRIDA

I. Family MONILIGASTRIDAE

1. Genus ***Drawida*** Michaelsen, 1900

1. ***Drawida nepalensis*** Michaelsen, 1907

(Plate Ia and b)

1907. *Drawida nepalensis Michaelsen, Mitt. Naturh. Mus. Hamb.*, **24** : 146. (Type locality : Gowchar near Katmandu, Nepal; types in Zoological Survey of India, Kolkata).

1995. *Drawida nepalensis*, Reynolds, Julka and Khan, *Megadrilogica*, **6** (6) : 56.

Diagnosis : Length 45-132 mm; diameter 2-4.5 mm. Segments 115-166. Setae lumbricine. Clitellum ix-xiv. Setae *aa* = or slightly >or <*bc*, *dd*; *ca.* = or slightly > ½ *c*. One small, circular, translucent genital marking, lateral to each male porophore, another similar one on vii, just anterior to each spermathecal pore. Nephropores at or near *d*. Spermathecal pores paired, small transverse slits, at 7/8, just median to *c*. Female pores paired, at *b* in 11/12. Male pores paired, at or median to *bc* in 10/11, on markedly protuberant porophores.

Septa all present from 4/5, 5/6-9/10 muscular. Gizzards 2-4, in xii-xx; intestinal origin in xxvii or xxviii. Intestinal caeca and supra-intestinal glands absent. Holonephridia in iii and posteriad segments. Nephridia of x lacking in adults. Capsular prostates paired, in x. Prostates glandular; prostatic capsule 2-4 mm long, club-shaped. Spermathecal ampulla irregularly pear-shaped; diverticulum sac-like, in vii. Genital marking glands solid, spheroidal.

Material Examined : 4 exs, MD; 14. x. 2001; 3 exs, MD; 11. xi. 2001; 6 exs, MD; 13. i. 2002; 8 exs, MD; 20. x. 2002; 10 exs, MD; 12. i. 2003; 4 exs, BRF; 18. viii. 2002; 14 exs, BRF; 19. i. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (North 24 Pgs., Nadia, Kolkata, Bankura, Coochbehar, Darjeeling, Jalpaiguri); Andaman and Nicobar Islands; Assam; Bihar; Himachal Pradesh; Meghalaya; Sikkim; Uttar Pradesh.

Elsewhere : PAKISTAN; NEPAL; BANGLADESH; MYANMAR; INDONESIA.

Remarks : No appreciable variation was observed in the present material. Only four specimens observed which have no genital markings.

2. ***Drawida papillifer papillifer*** Stephenson, 1917

(Plate IIa and b)

1917. *Drawida papillifer* Stephenson, *Rec. Indian Mus.*, **13** : 370. (Type locality : Rangamati, Chittagong Hill Tracts, Bangla Desh; Types in Zoological Survey of India, Kolkata.)

1995. *Drawida papillifer papillifer*, Reynolds, Julka and Khan, *Megadrilogica*, **6** (6) : 56.

Diagnosis : Length 60-130; diameter 3-5 mm, Segments 110-165. Clitellum, red, ix-xiv. Colour bluish. Setae lumbricine. Setae, *aa* < *bc*, *dd* = or > ½ *c*. Male pores, very small, superficial, without protrusible porophore, paired, in x, at or just lateral to *b* or nearer to middle of *bc*, each in a whitened semicircular area with base at 10/11. Spermathecal pores paired in 7/8, very small, at or slightly median to *c*. Genital markings, small, nearly circular transverse areas of translucence, in vii-viii and x-xi near spermathecal and male pores, occasionally in other positions on vii-xii. Nephropores at or near *d*, somewhat more dorsal in viii.

Septa 5/6-9/10 muscular. Gizzards, 2-4, in xiii-xx. Intestinal origin, in xxiii or xiv. Intestinal caeca and supra-intestinal glands absent. Holonephric. Sperm ducts, short, 5-10 mm long. Paired capsular prostates, in x. Prostates, 2-3 mm long. Spermathecal diverticula, saccular, with a short stalk, in vii. Genital marking glands, small, spheroidal, beneath longitudinal musculature.

Material Examined : 54 exs, MD; 14. x. 2001; 35 exs, MD; 13. i. 2002; 19 exs, MD; 14. iv. 2002; 13 exs, MD; 11. viii. 2002; 48 exs, MD; 12. i. 2003; 28 exs, MD; 9. ii. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (North 24 Pgs.); Meghalaya.

Elsewhere : BANGLADESH; MYANMAR.

Remarks : In India, so far, this species was known to occur only from Meghalaya. In this study it is newly recorded from West Bengal. No appreciable variation was observed in the present material.

Order HAPLOTAXIDA

Suborder LUMBRICINA

Superfamily MEGASCOLECOIDEA

II. Family OCTOCHAETIDAE

2. Genus : ***Eutyphoeus*** Michaelsen, 1900.

3. ***Eutyphoeus incommodus*** (Beddard, 1901)

(Plate III a and b)

1901. *Typhoeus incommodus* Beddard, *Proc. Zool. Soc. Lond.*, **1901** : 200. (Type locality : Kolkata, West Bengal; typus amissus.)

1903. ***Eutyphoeus incommodus***, Michaelsen, *Die geogr. Verbr. der Oligochaten* : 109.

1988. ***Eutyphoeus incommodus***, Julka, *Fauna of India, Megadrile Oligochaeta*, **1** : 145.

Diagnosis : Length 38-137 mm; diameter 2.5-5.5 mm. Segments 83-166. Setae lumbricine. Clitellum annular; xiii, ½ xiii-xvii, xviii. Paired genital markings, postsetal in *ab*, on xii, xiii-xvi. Dorsal pores present, first dorsal pore generally at 11/12, occasionally at 10/11. Spermathecal pores paired, small, transverse slits, slightly lateral to *b* in 7/8. Male pores paired, near to paired prostatic pores on xvii. Female pores paired, presetal, on xiv, at or slightly median to *a*. Avestibulate and apenile; male pores within slight transversely placed fissures, at or close to *b*, each fissure at the centre of a disc-shaped to slightly conical porophore.

Oesophagus with a single gizzard between septa 5/6 and 8/9, one pair of discrete, intramural calciferous glands in xii. Intestine begins in xv; Lateral intestinal caeca lacking; ventral intestinal caeca 3-9 in xxvii-xxxvi; supra-intestinal glands 3-6 pairs in lxii-lxxv; typhlosole simple, lamelliform, begins in xxv-xxvi. Dorsal blood vessel extends anterior to gizzard into iii; last pair of hearts in xiii. Holandric; testes and male funnels enclosed in annular sacs, in x and xi; seminal vesicles in ix and xii, extending posteriorly to xiii. Prostates paired, prostatic duct 2-6 mm long, slender. Penial setae almost straight, distal end slightly curved; tip bluntly rounded; ornamented. Prostates tubular. Spermathecae paired, in viii; ampulla globular, duct straight; polydiverticulate.

Material Examined : 2 exs, BRF; 18. v. 2003; 10 exs, BRF; 15. vi. 2003; 5 exs, BRF; 20. vii. 2003; 27 exs, MD; 10. vi. 2001; 26 exs, MD; 12. viii. 2001; 64 exs, MD; 9. ix. 2001; 44 exs, MD; 14. x. 2001; 11 exs, MD; 12. v. 2002; 14 exs, MD; 8. xii. 2002; 8 exs, MD; 9. iii. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (North 24 Pgs., Nadia, Kolkata, Birbhum, Murshidabad, West Dinajpur); Bihar; Hariana; Himachal Pradesh; Orissa; Punjab; Rajasthan; Uttar Pradesh.

Elsewhere : PAKISTAN.

Remarks : No appreciable variation was observed in the present material. Some variations were observed in the position of genital markings. Two specimens having paired genital markings extended to xvii and xviii.

4. ***Eutyphoeus nicholsoni*** (Beddard, 1901)

(Plate IVa and b)

1901. *Typhoeus nicholsoni* Beddard, *Proc. Zool. Soc. Lond.*, **1901** : 206. (Type locality : Kolkata, West Bengal, India; typus amissus.)

1903. *Eutyphoeus nicholsoni*, Michaelsen, *Die geogr. Verbr. der Oligochaten* : 109.

1988. *Eutyphoeus nicholsoni*, Julka, *Fauna of India, Megadrile Oligochaeta*, **1** : 158.

Diagnosis : Length 138-175 mm; diameter 5-5 mm. Segments 179-205. Setae lumbricine. Clitellum annular, xiii-xvii. Setae *a b* <*c d* <*b c* < *a a*. Genital markings paired, circular or oval, in 15/16. Dorsal pores present, first dorsal pore at 11/12. Spermathecal pores paired, at *ab*, in 7/8. Male pores paired, near to paired prostatic pores on xvii. Female pore single, on left side of xiv, presetal, at *a*. Bivestibulate and penile; vestibula deep and well-like, apertures transversely slit-like about in *ab*; penes elongate, tubular each with a slit-like aperture at the tip.

Oesophagus with a single gizzard between septa 5/6 and 8/9, one pair of discrete, intramural calciferous glands in xii. Intestine begins in xv. Lateral intestinal caeca lacking; median ventral intestinal caeca 24-30 in xxxv-lxix; supra intestinal glands 4-7 pairs in lxxx-lxxxxix, typhlosole simple, lamelliform, begins in xxviii-xxix. Dorsal blood vessel terminates posterior to gizzard in vii, rarely extending anteriorly to vi; last pair of hearts in xiii. Metandric; testis sac ventral; seminal vesicles in xii extending posteriorly to xiv. Prostates paired, coiled, duct muscular and long, in an S-shaped curve. Penial setae shaft nearly straight or gently curved ectally; tip bluntly rounded; ornamented. Prostates tubular. Spermathecal ampulla broad and lobed; polydiverticulate.

Material Examined : 3 exs, BRF; 18. v. 2003; 6 exs, BRF; 15. vi. 2003; 7 exs, BRF; 20. vii. 2003; 11 exs, BRF; 17. viii. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (Nadia, Kolkata, Birbhum, Murshidabad); Bihar; Uttar Pradesh; Madhya Pradesh; Himachal Pradesh.

Remarks : No appreciable variation was observed in the present material except 11 specimens where genital markings were absent.

5. ***Eutyphoeus orientalis*** (Beddard, 1883)

(Plate Va and b)

1883. *Typhoeus orientalis* Beddard. *Ann. Mag. Nat. Hist.*, (*ser.* 5), **12** : 219. (Type locality : Kolkata, West Bengal, India; typus amissus.)

1900. *Eutyphoeus orientalis*, Michaelsen, *Tierreich*, **10** : 322.

1988. *Eutyphoeus crientalis*, Julka, *Fauna of India, Megadrile Oligochaeta*, **1** : 161.

Diagnosis : Length 136-233 mm; diameter 5-8.5 mm. Segments 148-236. Setae lumbricine. Clitellum annular, xiv-xvi. Genital markings paired, postsetal, *ca*, on xv-xvi and in 18/19-20/21, occasionally on ix-x, xiii-xiv and 21/22-25/26. Dorsal pores present, first dorsal pore at 11/12. Spermathecal pores paired, in *bc*, in 7/8. Female pore single, on left side of xiv, presetal at *a*. Bivestibulate and penile; penes short and annular, each penes on the roof of a deep vestibulum; vestibular apertures circular to transversely elliptical in *ab*.

Oesophagus with a single large gizzard between septa 5/6 and 8/9, one pair of discrete, intramural calciferous glands in xii. Intestine begins in xv; lateral intestinal caeca lacking; median ventral intestinal caeca 30-34 in xxiv-lxvii, supra-intestinal glands 4-7 pairs in lxxxvi-xcvi, typhlosole simple, lamelliform, begins in xxviii. Dorsal blood vessel terminates posterior to gizzard in vii; last pair of hearts in xiii. Metandric; testis sac ventral; seminal vesicles in xii, long, extending back to several segments. Prostates paired large coiled tubes; duct thinner. Penial setae straight; tip simple, bluntly rounded with spoon-shaped concavity. Prostates tubular. Spermathecal ampulla an ovoidal sac; duct short, stout and muscular; bidiverticulate; diverticulum one median and one lateral.

Material Examined : 8 exs, MD; 10. vi. 2001; 43 exs, MD; 8. vii. 2001; 10 exs, MD; 9. xii. 2001; 6 exs, MD; 12. v. 2002; 60 exs, MD; 11. viii. 2002; 11 exs, MD; 11. v. 2003; 5 exs, BRF; 17. vi. 2001; 4 exs, BRF; 15. vii. 2001; 9 exs, BRF; 18. v. 2003; 15 exs, BRF; 15. vi. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (North 24 Pgs., Nadia, Kolkata, Birbhum, Murshidabad, Hooghly, Howrah, South 24 Pgs.); Bihar; Uttar Pradesh.

Elsewhere : BANGLADESH.

Remarks : Variations were found among 5 specimens having genital markings extended to xviii, one specimen having genital markings on right side of xix and xxi but no appreciable variation was observed in the present material.

3. Genus ***Octochaetona*** Gates, 1962

6. ***Octochaetona beatrix*** (Beddard, 1902)

(Plate VIa and b)

1902. *Octochaetus beatrix Beddard, Ann. Mag. Nat. Hist.* (*ser.* 7), **9** : 456. (Type locality : Kolkata, West Bengal, India; types in Brit. Mus. (Nat. Hist.) London.)

1962. *Octochaetona beatrix*, Gates, *Ann. Mag. Nat. Hist.* (*ser.* 13), **5** : 213.

1988. *Octochaetona beatrix*, Julka, *Fauna of India, Megadrile Oligochaeta*, 1 : 271.

Diagnosis : Length 35-128 mm; diameter 2-4 mm. Segments 129-186. Prostomium epilobic, tongue closed. Clitellum annular, xiii-xvii. Setae lumbricine, setae $ab < cd < bc < aa$, $dd > ½ c$. Dorsal pores present, first dorsal pore at 12/13, occasionally at 11/12. Spermathecal pores minute, at or slightly anterior to setal arcs of viii and ix, close to midventral line. Female pores paired presetal, in *aa*, on xiv. Prostatic pores paired, minute, median to *a*. Seminal grooves concave between setal arcs of xvii and xix, at or median to *a* line. Male field depressed; male pores paired, minute, at or slightly median to *a*, on xviii.

Septa 5/6-7/8 absent and 4/5, 8/9-11/12 muscular. Gizzard between 4/5 and 8/9; calciferous glands one pair, discrete, extramural, shortly and slenderly stalked, asymmetrical, opening into oesophagus close to the attachment of septum 15/16, one gland in xv and the other in xvi, intestinal origin in xvii; intestinal caeca and supra intestinal glands absent; typhlosole lamelliform, ventrally bifid, in xxv to civ-cxii. Dorsal vessel single and complete, last pair of hearts in xiii. Metandric; testes and male funnels enclosed in a sub-oesophageal U-shaped sac, in xi, male funnels present in x; seminal vesicles small, in xii. Prostates paired in xvii and xix; duct thin and short. Penial setae curved; tip pointed; ornamented. Prostates tubular. Spermathecae paired, in viii and ix; ampulla small, ovoid, beneath the gut; duct muscular and shorter than ampulla; unidiverticulate; diverticulum spherodial.

Material Examined : 4 exs, BRF; 18. viii. 2002; 1 ex, BRF; 15. ix. 2002; 2 exs, BRF; 20. vii. 2003; 3 exs, BRF; 17. viii. 2003; A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (Nadia, Kolkata, Burdwan, Murshidabad, Darjeeling, South 24 Pgs.); Assam; Gujarat; Himachal Pradesh; Karnataka; Jammu and Kashmir; Rajasthan; Kerala; Madhya Pradesh; Maharashtra; Orissa; Punjab; Uttar Pradesh.

Elsewhere : PAKISTAN; NEPAL; MALAY PENINSULA; MYANMAR; PHILIPPINES.

Remarks : No appreciable variation was observed in the present material.

7. ***Octochaetona surensis*** (Michaelsen, 1910)

(Plate VIIa and b)

1910. *Octochaetus surensis* Michaelsen, *Abh. Geb. Naturw. Hamburg*, **19** (5) : 88. (Type locality: Sur Lake, Puri Dist., Orissa, India; Typus amissus).

1962. *Octochaetona surensis*, Gates, *Ann. Mag. Nat. Hist.* (*ser.* 13), **5** : 213.

1988. *Octochaetona surensis*, Julka, *Fauna of India, Megadrile Oligochaeta*, **1** : 292.

Diagnosis : Length 65-130 mm, diameter 3-5 mm, 102-160 segments. Prostomium epilobic, tongue closed. Dorsal pores present, first dorsal pore 12/13. Clitellum annular, xiii-xvii. Setae lumbricine, setae *aa* = 2.1-4.1 *ab* = 1-1.1 *bc* = 1.2-2.1 *cd* = 0.15-0.2 *dd* on xii. Setae *a*, *b* on viii and ix copulatory, this encircled by developed tumescences. Male genital field xvi-xx, with deep depressions on xvii and xix. Male pores paired minute, median to *b*, on xviii. Prostatic pores paired minute at *b*. Female pores paired, presetal, in *a* lines, on xiv. Spermathecal pores paired, minute, on viii and ix, at *ab*. Genital markings on some of xviii-xxii, at *aa* or *bb*.

Septa 5/6/7/8 absent and 4/5, 8/9-10/11 muscular. Gizzard between septa 4/5 and 8/9. Calciferous glands one pair, discrete, extramural, shortly and slenderly stalked, asymmetrical, close to the attachment of septum 15/16, one gland in xv and the other in xvi, intestinal origin in xvii; intestinal caeca and supra intestinal glands absent; typhlosole lamelliform, ventrally bifid, in xxii-xxiii to ci-cxv. Dorsal vessel single and complete. Last pair of hearts in xiii. Holandric, seminal vesicles in ix and xii. Penial setae ornamented. Prostates tubular. Sparmathecae paired in viii and ix, each with a shortly stalked diverticulum. Copulatory setae ornamented.

Material Examined : 5 exs, MD; 9. ix. 2001; 2 exs, MD; 14. x. 2001; 1 ex, MD; 9. vi. 2002; 5 exs, MD; 8. ix. 2002; 3 exs, MD; 20. x. 2002; 1 ex, MD; 11. v. 2003; 1 ex, MD; 8. vi. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (North 24 Pgs.) Assam; Madhya Pradesh; Orissa; Uttar Pradesh.

Elsewhere : MYANMAR.

Remarks : This is recorded for the first time from West Bengal. Variations were observed in the male genital field region of 11 specimens, the area of which was nearly hexagonal in shape.

III. Family MEGASCOLECIDAE

4. Genus *Lampito* Kinberg, 1867

8. *Lampito mauritii Kinberg*, 1867

(Plate VIII a and b)

1867. *Lampito mauritii* Kinberg, *Ofvers. K. Vetens. Akad. Forhandl. Stockholm*, **23** : 103. (Type locality : Mauritus; types in Naturhistoriska Riksmuseet, Stockholm).

1995. *Lampito mauritii*, Reynolds, Julka and Khan, *Megadrilogica*, **6**(6) : 54.

Diagnosis : Length 89-145 mm; diameter 3-5.5 mm. Segments 151-192. Prostomium prolobic. Clitellum annular in 13/14-17/18. Setae perichaetine, 40-48 on viii. 30-39 on xx, 10-15 between spermathecal pores and none between male pores. Dorsal pores present, first dorsal pore at 10/11-12/13. Spermathecal pores 3 pairs, large, in *eg*, in 6/7-8/9. Female pores closely paired, presetal, within *aa*, on xiv. Male pores paired, on slightly raised porophore, at or lateral to *b*, on xviii.

Septa all present from 4/5, 7/8-12/13 muscular. Digestive system with a single oesophageal gizzard in v. Intestinal origin in xv, typhlosole rudimentary, but intestinal caeca and supra intestinal glands absent. Last pair of hearts in xiii. Meronephric. Holandric; testes free in x and xi; seminal vesicles in xi and xii. Biprostatic, prostates racemose, in xviii; duct straight. Penial setae with horseshoe-shaped or scoop-shaped tips, ornamented. Sexthecal, in vii-ix; each spermathecae with median and lateral digitiform diverticula; ampulla elongate; duct barrel shapped.

Material Examined : 17 exs, BRF; 15. vii. 2001; 24 exs, BRF; 19. viii. 2001; 3 exs, BRF; 15. xii. 2002; 49 exs, BRF; 20. vii. 2003; 51 exs, BRF; 17. viii. 2003; 70 exs, DP; 3. vi. 2001; 106 exs, DP; 1. vii. 2001; 68 exs, DP; 6. i. 2002; 77 exs, DP; 7. iv. 2002; 8 exs, DP; 2. ii. 2003; 48 exs, DP; 2. iii. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (Nadia, Kolkata, Burdwan, Bankura, Birbhum, Coochbehar, Darjeeling, Jalpaiguri, Murshidabad, Malda, Midnapur, Purulia, West Dinajpur, South 24 Pgs., North 24 Pgs., Howrah); Andaman and Nicobar Islands; Andhra Pradesh; Bihar; Gujarat; Karnataka; Kerala; Laccadive and Minicoy Islads; Madhya Pradesh; Maharashtra; Orissa; Rajasthan; Tamil Nadu; Uttar Pradesh.

Elsewhere : PAKISTAN; SRI LANKA; CHINA; MALDIVES; THAILAND; BANGLADESH; HONG KONG; SEYCHELLES IS.; NEW CALEDONIA; MAURITUS; MADAGASCAR; COMORO IS.; INDONESIA; MALAY PENINSULA; MYANMAR; PHILIPPINES; ZANZIBAR.

Remarks : Some variations have been observed in the morphology. In two specimens spermathecal pores are present in v, vi and vii. Two specimens have found with male pores on xvii and female pore on xiii. One specimen with unidiverticulate spermathecae in the left side of vi and vii. Penial setae in seven specimens were only one pair.

5. Genus ***Metaphire*** Sims and Easton, 1972

9. ***Metaphire posthuma*** (Vaillant, 1868)

(Plate IXa and b)

1868. *Perichaeta posthuma* Vaillant, *Annl Sci. Nat.*, (*ser.* 5), **10** : 228. (Type locality : Java; types in Museum National d' Historic Naturelle, Paris).

1972. *Metaphire posthuma*, Sims and Easton, *Biol. J. Linn. Soc.*, **4** (3) : 239.

1995. *Metaphire posthuma*, Reynolds, Julka and Khan, *Megadrilogica*, **6** (6) : 54.

Diagnosis : Length 56-132 mm; diameter 3-6.5 mm. Segments 81-114. Prostomium epilobic, tongue open. Clitellum annular, xiv-xvi. Setae perichaetine, setae present on clitellar segments ventrally, 103-125 on viii, 75-91 on xx 33-41 between spermathecal pores and 16-22 between male pores. Genital markings paired, circular in setal circle, slightly median to male pore line, usually on xvii and xix. Dorsal pores present, first dorsal pore at 12/13. Spermathecal pores 4 pairs, minute and superficial, in 5/6-8/9. Female pore single, mid-ventral, presetal on xiv. Male pores, minute on xviii. Opening of male copulatory pouches circular.

Septa 5/6-8/9 muscular, 9/10 lacking. Oesophagus with a single gizzard between septa 7/8 and 9/10; intestinal origin in xv; intestinal caeca paired, simple, originating in xxvii and extending forward to xxiv; typhlosole simple, lamelliform; supra intestinal glands absent. Last pair of hearts in xiii. Meronephric. Holandric; seminal vesicles in xi and xii, former is larger. Prostates racemose, in xv-xxi; each in a U-shaped loop. Octothecal; ampulla ovoid; duct shorter than ampulla; unidiverticulate, diverticulum arises from median face of duct. Genital marking glands sessile.

Material Examined : 3 exs, BRF; 15. vii. 2001; 6 exs, BRF; 19. viii. 2001; 2 exs, BRF; 19. v. 2002; 5 exs, BRF; 24. xi. 2002; 17 exs, BRF; 20. vii. 2003; 5 exs, MD; 10. vi. 2001; 3 exs, MD; 8. vii. 2001; 8 exs, MD; 9. vi. 2002; 7 exs, MD; 11. viii. 2002; 9 exs, MD; 10. viii. 2003; 1 ex, DP; 3. vi. 2001; 2 exs, DP; 1. vii. 2001; 6 exs, DP; 5. viii. 2001; 2 exs, DP; 5. v. 2002; 8 exs, DP; 1. xii. 2002; 15 exs, DP; 1. vi. 2003; 11 exs, DP; 3. viii. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (Nadia, Kolkata, North 24 Pgs., Burdwan, Bankura, Coochbehar, Jalpaiguri, Murshidabad, Malda, Midnapur, West Dinajpur, South 24 Pgs., Howrah); Andaman Islands; Himachal Pradesh; Jammu and Kashmir; Bihar; Gujarat; Hariana; Madhya Pradesh; Maharashtra; Orissa; Rajasthan; Punjab; Uttar Pradesh.

Elsewhere : PAKISTAN; THAILAND; BANGLADESH; VIETNAM; INDONESIA; MALAY PENINSULA; MYANMAR; PHILIPPINES; U.S.A.

Remarks : No appreciable variations were found in the present material. In two specimens an extra structure like genital markings have observed on xx.

10. ***Metaphire houlleti*** (Perrier, 1872)

(Plate Xa and b)

1872. ***Perichaeta houlleti*** Perrier, *Nouv. Arch. Mus. Hist. Nat. Paris*, **8** : 99. (Type locality : Kolkata, West Bengal, India; types in Musum National d' Historie Naturelle, Paris).

1972. ***Metaphire houlleti houlleti, h. rugosa; campanulata campanulata, c. meridiana, c. penitralis; Wimberleyana***, Sims and Easton, *Biol. J. Linn. Soc.*, **4** (3) : 238.

1982. ***Metaphire houlleti***, Julka, *Rec. Zool. Surv. India*, **80** : 142.

Diagnosis : Length 46-191 mm; diameter 3-6.5 mm. Segments 85-132. Prostomium epilobic, tongue open. Clitellum annular, xiv-xvi. Setae perichaetine, setae often present in clitellar segments, 30-50 on viii, 46-60 on xx, 13-28 between spermathecal pores and 4-13 between male pores. Dorsal pores present, first dorsal pore in region of 9/10-11/12. Spermathecal pores 3 pairs, minute, ca, in 6/7-8/9. Female pore single, mid-ventral, on xiv. Male pores minute, on xviii, each pore on a penial body.

Septa 8/9-9/10 lacking. Oesophagus with a single gizzard between septa 7/8 and 9/10; Intestinal origin in xv; intestinal caeca paired, simple, originating in xxvii and extending forward to xxii, typhlosole simple, lamelliform; supra intestinal glands absent.

Last pair of hearts in xiii. Meronephric. Holandric; testis sacs unpaired and ventral in x and xi; seminal vesicle in xi and xii. Sexthecal; spermatheca unidiverticulate; diverticulum arises from ectal end of duct. Genital marking glands stalked.

Material Examined : 3 exs, BRF; 20. vii. 2003; 3 exs, BRF; 17. viii. 2003; 1 ex, MD; 9. ix. 2001; 7 exs, MD; 14. x. 2001; 2 exs, MD; 14. vii. 2002; 4 exs, MD; 8. ix. 2002; 8 exs, MD; 20. x. 2002; 1 ex, MD; 13.vii. 2003; 3 exs, MD; 10. viii. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (Nadia, North 24 Pgs., Burdwan, Bankura, Birbhum, Murshidabad, South 24 Pgs., Darjeeling, Howrah); Andaman and Nicobar Islands; Meghalaya, Uttar Pradesh.

Elsewhere : PAKISTAN; CHINA; THAILAND; BANGLADESH; INDONESIA; MALAY PENINSULA; MYANMAR; PHILIPPINES; U.S.A; WEST INDIES; BAHAMAS; CUBA.

Remarks : No appreciable variations were found in the present material.

6. Genus *Perionyx* Perrier, 1872

11. *Perionyx excavatus* Perrier, 1872

(Fig. 33, Plate XIa and b)

1872. *Perionyx excavatus* Perrier, *Nouv. Arch. Mus. Hist. Nat. Paris*, **8** : 126. (Type locality : Saigon, Vietnam; types in Museum National d' Historic Naturelle, Paris).

1995. *Perionyx excavatus*, Reynolds, Julka and Khan, *Megadrilogica*, **6** (6) : 55.

Diagnosis : Length 41-173 mm; diameter 3-5 mm. Segments 119-168. Colour dorsally deep purple, ventrally pale. Prostomium epilobic, tongue open. Clitellum annular, xiii-xvii. Setae perichaetine, setae 43-53 on ix, 46-49 on xx, 4-5 between spermathecal pores. Nephridiopores inconspicuous. Dorsal pores present, first dorsal pore at any of 2/3-5/6. Spermathecal pores 2 pairs, near mid-ventral line, in 7/8 and 8/9. Female pore unpaired, median, presetal on xiv. Male pores in small transverse protuberances within a common field on xviii.

Septa all present from 4/5. Gizzard rudimentary in v; oesophagus widened in xiii with calciferous ridges, intestinal origin in xv or xvi, intestinal caeca, supra-intestinal glands and typhlosole absent. Last pair of hearts in xii. Holonephric. Holandric, testes free in x and xi; seminal vesicles in xi and xii, those of xii extend to septum 14/15. Prostates racemose in xviii; ducts straight. Penial setae ornamentd, tip bluntly rounded or finely pointed. Quadrithecal; ampulla large; duct short and stout.

Material Examined : 9 exs, BRF; 17. vi. 2001; 4 exs, BRF; 15. vii. 2001; 22 exs, BRF; 20. i. 2002; 7 exs, BRF; 18. viii. 2002; 14 exs, BRF; 16. ii. 2003; 23 exs, BRF; 16. iii. 2003;

19 exs, BRF; 20.iv. 2003; 4 exs, MD; 10. vi. 2001; 7 exs, MD; 8. vii. 2001; 4 exs, MD; 13. i. 2002; 6 exs, MD; 14. iv. 2002; 10 exs, MD; 12. v. 2002; 12 exs, MD; 9. iii. 2003; 15 exs, MD; 8. vi. 2003; 19 exs, DP; 6. iv. 2003; 16 exs, DP; 4. v. 2003; 8 exs, DP; 1. vi. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (Nadia, Kolkata, North 24 Pgs., Burdwan, Bankura, Coochbehar, Darjeeling, Hooghly, Jalpaiguri, Murshidabad, Malda, Midnapur, Purulia, West Dinajpur, South 24 Pgs., Howrah); Andaman Islands; Arunachal Pradesh; Assam; Himachal Pradesh; Manipur; Sikkim; Maharashtra; Orissa; Tamil Nadu; Uttar Pradesh.

Elsewhere : SRI LANKA; THAILAND; MADAGASCAR AND ITS ADJACENT ISLANDS; INDONESIA; MALAY PENINSULA; MYANMAR; PHILIPPINES; TAIWAN; WEST INDIES.

12. ***Perionyx simlaensis*** (Michaelsen, 1907)

(Plate XIIa and b)

1907. *Perionychella simlaensis* Michaelsen, *Mt. Mus. Hamburg*, **xxiv** : 157. (Type locality : Dharampur, Simla Hills.)

1923. *Perionyx simlaensis*, Stephenson, *The Fauna of British India, Oligochaeta* : 359.

Diagnosis : Length 85-121 mm; diameter 3-5 mm. Segments 95-128. Colour violet-red; ventrally whitish. Prostomium epilobic. Dorsal pores from 4/5 or 5/6. Setae much closer ventrally than dorsally; setae 45 on v, 46 on viii, 52 on xii, 45 on xix, 43 on xxvi. Clitellum annular, xiii-xvii. Male genital area in xviii, rectangular with rounded angles, containing a pair of swollen disc, each of which bears rod shaped penes. Combined male and prostatic pores are in the middle of the disc. Setae absent between the male pores. Female pore minute at mid-ventral line in xiv. Spermathecal pores in 7/8 and 8/9 at *c* line.

Gizzard very small, in v. Intestines begins in xvii; calciferous glands, typhlosole, intestinal caeca and supra intestinal glands absent. Last pair of hearts in xiii. Holonephric. Holandric, testes and funnels free in x and xi. Seminal vesicles three / four pairs, in x-xii or x-xiii. Prostates disc-shaped, duct with loop. Penial setae absent. Spermathecae paired in vii and viii. Spermathecal ampulla large, globoid, with numerous pears shaped projections; duct much shorter and thinner than the ampulla; seminal chambers unrecognizable.

Material Examined : 1 ex, MD; 8. vii. 2001; 2 exs, MD; 14. iv. 2002; 2 exs, MD; 12. v. 2002; 4 exs, MD; 9. iii. 2003; 2 exs, MD; 13. iv. 2003; 3 exs, MD; 8. vi. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (North 24 Pgs.); Himachal Pradesh, Uttar Pradesh.

Remarks : This species is previously known from western part of the gangetic plains and foothills of the Western Himalaya. Its' present record from West Bengal of great significance.

7. Genus ***Polypheretima*** Michaelsen, 1934

13. ***Polypheretima elongata*** (Perrier, 1872)

(Plate XIIIa and b)

1872. *Perichaeta elongata* Perrier, *Nouv. Arch. Mus. Hist. Nat. Paris*, **8** : 124. (Type locality : Peru; types in Museum National d' Histoire Naturelle, Paris.)

1979. *Polypheretima elongata*, Easton, *Bull. Br. Mus. Nat. Hist. (Zool.)*, **35** : 53.

1995. *Polypheretima elongata*, Reynolds, Julka and Khan, *Megadrilogica*, **6** (6) : 55.

Diagnosis : Length 45-388 mm; diameter 3-10 mm. Segments 146-281. Prostomium rudimentary. Clitellum annular, in xiv-xvi. Setae perichaetine, setae 61-101 on viii, 51-71 on xx, 11-19 between spermathecal pores and 7-13 between male pores. Genital markings transversely elliptical, paired, presetal on xix and successive segments in line with or slightly median to male pores, occasionally on vi, vii and xvii. Dorsal pores present, first dorsal pore at 12/13. Spermathecal pores when present, in paired groups of 2-5, at intersegmental furrows 5/6/7, minute and superficial. Female pore single, mid-ventral, on xiv. Male pores paired, on squat penes within shallow copulatory pouches, *ca*, on xviii. Opening of male copulatory pouches longitudinal.

Septa 8/9-9/10 absent. Oesophageal gizzard single, in viii; Intestinal origin in xv; intestinal caeca absent. Last pair of hearts in xii. Holandric; testis sacs large, unpaired and annular in x and xi; seminal vesicles in xi and xii. Prostates racemose, in xvi-xxi; ducts 2-5 mm long and looped. Polythecal; small spermathecal batterirs in 5/6 and 6/7 or 5/6 or 6/7 only or absent; unidiverticulate; diverticulum arises from ectal end of duct. Genital marking glands sessile on parietes.

Material Examined : 4 exs, MD; 9. ix. 2001; 7 exs, MD; 14. x. 2001; 6 exs, MD; 11. xi. 2001; 4 exs, MD; 9. xii. 2001; 2 exs, MD; 14. vii. 2002; 2 exs, MD; 8. ix. 2002; 10 exs, MD; 20. x. 2002; 3 exs, MD; 10. xi. 2002; 4 exs, MD; 10. viii. 2003. A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (North 24 Pgs., South 24 Pgs., Kolkata); Andaman and Nicobar Islands; Andhra Pradesh; Karnataka; Maharashtra; Madhya Pradesh; Tamil Nadu.

Elsewhere : AFRICA; SRI LANKA; THAILAND; MADAGASCAR; COMORO IS.; PAKISTAN; BANGLADESH; MYANMAR; INDONESIA; MALAY PENINSULA; PHILIPPINES; TAIWAN; INDONESIA; AUSTRALIA; PAPUA NEW GUINEA; NEW CALEDONIA; WEST INDIES; SOUTH AMERICA; TAHITI; CAROLINE IS.

Remarks : No appreciable variations were recorded in the present material. One specimen without genital marking on right side of xxiii, one without genital marking on left side of xxiv. In two specimens genital markings absent on right side of both xxiii and xxiv. Three specimens having no genital markings.

8. Genus ***Amynthas*** Kinberg, 1867

14. ***Amynthas corticis*** (Kinberg, 1867)

(Plate XIVa and b)

1867. *Perichaeta corticis* Kinberg, *Ofvers K. Vetens Akad. Forhandl. Stockholm.*, **23** : 102

1981. *Amynthas corticis*, Easton, *Bull. Br. Mus. Nat. Hist. (Zool.)*, **40** (2) : 49.

1995. *Amynthas corticis*, Julka, *Fauna West Himalaya.*, 1 : 18.

Diagnosis : Length 41-166 mm; diameter 3-5.5 mm. Segments 71-119. Prostomium epilobic, tongue open. Clitellum annular, xiv-xvi. Setae perichaetine, setae 23-41 on viii, 32-51 on xx, 6-13 between spermathecal pores and 8-13 between male pores. Gential markings small, circular to shortly elliptical discs, paired-presetal, just median to the line of spermathecal pores in some or all or vi-ix; post setal, just in front of spermathecal pores in some or all of v-viii, occasionally one or more near each male porophore on xviii. Dorsal pores present, first dorsal pore usually at 11/12. Spermathecal pores 4 pairs, minute, superficial, each in a small circular to transversely elliptical disc in 5/6-8/9. Female pore midventral, on xiv.

Septa 8/9-9/10 lacking. Gizzard large, somewhat conical; intestinal origin usually in xvi; typhlosole lamelliform; intestinal caeca simple extending forward to xxii. Last pair of hearts in xiii. Meronephridial. Holandric; testis sacs unpaired and ventral; seminal vesicles in xi and xii. Prostates racemose, xvi-xxii; ducts muscular and looped. Octothecal; ampulla inverted pearshaped, duct shorter than ampulla; unidiverticulate; diverticulum arises from anterior face of duct. Genital marking glands stalked and coelomic.

Material Examined : 2 exs, BRF; 18. viii. 2002; 2 exs, BRF; 15. ix. 2002; 1 ex, BRF; 17. viii. 2003; A. Chowdhury collected all specimens.

Distribution : INDIA : West Bengal (Nadia, Darjeeling, Jalpaiguri); Arunachal Pradesh; Assam; Himachal Pradesh; Jammu and Kashmir; Manipur; Karnataka; Sikkim; Meghalaya; Tamil Nadu; Uttar Pradesh.

Elsewhere : AFRICA; SRI LANKA; THAILAND; MADAGASCAR AND ITS ADJACENT ISLANDS; BANGLADESH; BHUTAN; CHINA; KOREA; JAPAN; NEPAL; MYANMAR; INDONESIA; PHILIPPINES; TAIWAN; HONG KONG; INDONESIA; AUSTRALIA; NEW ZEALAND; WEST INDIES; SOUTH AMERICA.

Remarks : No appreciable variations were observed in the present material.

ECOLOGY OF EARTHWORM FAUNA AND MICROBIAL FLORA IN STUDIED SITES

The present investigation involves extraction of earthworm fauna and microorganisms from the soil samples of 12 sampling plots in three different habitats such as, I. Municipal wastes disposal site at Dhapa, Kolkata (DP); II. Uncultivated field site at Madhyamgram, North 24 Pgs. District (MD) and III. Bethuadahari Reserve Forest, Nadia District (BRF) of West Bengal (Map 1), a state in the Eastern region of the Indian Republic situated between 22° N - 27° N and 86° E - 89° E.

SITE – I - Dhapa, Municipal wastes disposal site of Kolkata (DP)

Characteristics of sampling site : The site is dumping ground of city wastes, located by the side of Eastern Metropolitan bypass, Kolkata (Map 1). It included four sampling plots, each measuring nearly 100 metre square. The main constituents of the dumped materials were household wastes, residues of vegetables etc. Some parts of these plots were used for cultivation of different seasonal vegetables like cauliflower, maize, cucurbita, lettuce, cabbage etc. (Plate XV).

Vegetation : The plots were covered with grasses, sedges and herbs like, *Cynodon dactylon*, *Commelina bengalensis*, *Cyperus rotundus*, *Digitaria adscendens*, *Echinochloa colonum* and margins of the plots with few scattered trees like *Accacia arabica*.

Soil Factors : Soil of these plots was Gangetic alluvium in nature, blackish in colour and silty sand to sandy loam in texture with well developed humus mainly comprised of decomposed and semi decomposed litter. pH varied from 6.5 to 7.38 and electrical conductivity varied from 0.18 to 1.5 dSm^{-1} (Tab. 2). During August in each sampling year subsoil relative humidity in the soil was maximum 96% in 2001, 100% in 2002 and 98% in 2003 and subsoil temperature was at that time 29°C in both 2001 and in 2002 and 27°C in 2003. In August other soil factors like organic Carbon were 3.86% in 2001, 3.73% in 2002 and 4.1% in 2003 and available Nitrogen were 386 $Kgha^{-1}$ in 2001, 475 $Kgha^{-1}$ in 2002 and 510 $Kgha^{-1}$ in 2003. During the month of January and February 2003, subsoil humidity was 80% and 82% and subsoil temperature was at that time 22°C and 20°C, respectively. In January other soil factors such as organic Carbon, available Nitrogen, available P_2O_5 and available K_2O were 3.29%, 356 Kg ha^{-1}, 185 Kg ha^{-1} and 494 Kg ha^{-1}, respectively in 2002 and 3.46%, 395 Kg ha^{-1}, 102 Kg ha^{-1} and 644 Kg ha^{-1}, respectively in

2003 (Tab. 2). Mechanical analysis of soil sample showed maximum percentage of coarse sand 57.95% (Tab. 1).

Heavy Metals : Month wise mean concentration of heavy metals (Cd, Zn, Pb and Cu) obtained from soil samples have been shown in Tab. 2, from which it would be evident that, in this polluted site, in the month of August the concentration of heavy metals such as Cadmium, Zinc, Lead and Copper were comparatively low (3 ppm, 600 ppm, 270 ppm and 170 ppm, respectively in 2003). While, in the month of February and March 2003, except Copper the concentrations of heavy metals were found to be high in this site (Tab. 2).

Earthworm Fauna : The earthworm fauna obtained from this site belonged to three species under three genera. The species *Lampito mauritii* was the most dominant form being collected from all the soil samples and comprising 94.3% of the total population collected from this site. *Metaphire posthuma* and *Perionyx excavatus* comprising 3.34% and 2.05% occupied second and third position, respectively (Tab. 3; Fig. 1). Number of earthworm obtained in each month (Tab. 2) showed maximum populations usually in August when soil factors like relative humidity, organic Carbon, available Nitrogen, available P_2O_5 and available K_2O were all at higher levels; whereas heavy metals such as Cadmium, Zinc, Lead and Copper were minimum (Figs. 2-9 and 10-13). Increase of population in July-September as obtained in this site might be due to prevalence of optimum conditions of different soil factors (Tab. 2 and Figs. 2-9).

Seasonal Changes : The total populations of earthworm obtained from this site were maximum in August in each sampling year (Figs. 2-9). Seasonal changes of each species of earthworm obtained from this site revealed that, *Lampito mauritii* had August peak in all the year, this might be due to higher humidity, organic Carbon and low heavy metals concentration in this month. Second peak was in the month of September and third peak was in the month of July. Lowest population was found in the month of January and February 2003; this might be due to the lower subsoil temperature, subsoil humidity, available K_2O and higher concentration of soil heavy metals (Tab. 2). While other species population was numerically very low, the *Metaphire posthuma* showed maximum peak in the month of June 2003 but in 2002 the peak was shifted to December. *Perionyx excavatus* was found only in the year 2003 and showed its peak in the month of April. In spite of higher heavy metal contents, second population peak of *Lampito mauritii* was found in the year September 2002. This may be because it can withstand toxic pressure of heavy metals to some extent (Tab. 2).

Microbial flora

Fungi : The soil fungi obtained from this site belonged to seven genera. The genus *Penicillium* sp. was the most dominant occupying 61.95% of the total fungal population obtained from this site. The genus *Aspergillus* sp. constituted 17.93% while *Fusarium* sp.

constituted 6.09% of total population. Other genera recorded were numerically poor and irregular in occurrence (Tab. 5; Fig. 14). The maximum percentage representation of fungi encountered in August in every studied year found to be coincided with the higher population of earthworm, bacteria-actinomycetes as well as maximum concentration of soil factors like relative humidity, organic Carbon, nitrate, phosphate and also minimum concentration of soil heavy metals (Tab. 4; Figs. 16-24 and 25-28).

Seasonal Changes : Fungi populations were maximum in the month of August in all the sampling years (Figs. 17-24). The *Penicillium* sp. had its peak in September in each year of observation. *Aspergillus* sp. had its peak in July in each year of observation. The maximum abundance of other genera varied among years as well as in months of observation due to their irregular occurrence in this field (Tab. 5). In January 2003 and May 2003, absence of some genera and poor occurrence of the dominant resulted in minimum population density of total fungal community.

Bacteria-Acinomycetes : The soil bacteria-actinomycetes obtained from this site belonged to eleven genera. The genus *Bacillus* sp. was the most dominant and represented 43.33% of the total population recorded. The genus *Streptomyces* sp. occupied 24.07% and *Micrococcus* sp. occupied 13.55%. In addition some more genera were also recorded from this field but, their occurrences were irregular (Tab. 6, Fig. 15). A maximum population of 8.29% was found in August 2003 and 7.18%, 6.14% observed in September 2002 and August 2001, respectively (Tab. 6). The high percentage of total bacteria-actinomycetes during this period coincided with the high concentration of soil factors like relative humidity, organic Carbon, nitrate, phosphate and also minimum concentration of soil heavy metals (Tab. 4; Fig. 17-24 and 25-28). The minimum population recorded in the month of April and May, 2002 and in February, 2003, coincided with that of lower population of earthworm and fungi as well as minimum content of soil relative humidity, phosphate and maximum concentration of soil heavy metals (Tab. 4; Figs. 16-24 and 25-28).

Seasonal Changes : Bacteria-actinomycetes population showed its peak in the month of August in 2001, September in 2002 and again in the month of August in 2003 (Figs. 17-24). It is evident that, population peak of dominant genera varied among years as well as in months of observation. The population of *Bacillus* sp. showed its peak in August 2001, September 2002 and August 2003. Lowest population was found in April 2002 and February 2003. However, in remaining months it remained more or less high with slight fluctuation. Another dominant genus *Streptomyces* sp. showing wide fluctuation, its population peaks were recorded in July 2002 and August 2003. The population of *Micrococcus* sp. showed fluctuation with the highest peak in August 2001 and September 2002, with little variation among *Micrococcus* I and II. The other genera also revealed irregular population peak due to their infrequent occurrence in this field. In January and February 2003, absence of some genera accompanied with low population of predominant genera resulted in the minimum population density of Bacteria-acinomycetes population (Tab. 6).

SITE – II - Madhyamgram, Uncultivated field, North 24 Pgs. (MD)

Characteristics of sampling site : The site is nearly 40 km north from Kolkata, in the district of North 24 pgs., West Bengal (Map 1). It included four sampling plots, each 100 metre square (approx.). In these plots no cultivation is being made. Scattered cowdungs were also found due to occasional visit of the domestic cattle in this field (Plate XVI).

Vegetation : The plots were covered with grasses, sedges and herbs like, *Cynodon dactylon, Euphorbia hirta, Chrysopogon aciculatus, Solanum nigram, Centella asiatica, Coccinia cordifolia, Eclipta prostrata, Marsilea minuta, Colocasia esculenta.* The other vegetations mainly belong to *Mangifera indica* and *Annona squamosa, Cocos nucifera, Musa paradisiaca.*

Soil Factors : Soil of these plots was Gangetic alluvium in nature, brown in colour and clay silt loam in texture. pH varied from 5.66 to 7.4 and electrical conductivity varied from 0.1 to 1.5 dSm^{-1} (Tab. 7). During October in each sampling year subsoil relative humidity in the soil was maximum 90% in 2001 and 95% in 2002 and subsoil temperature was at that time 25°C in 2001 and 26°C in 2002. Subsoil relative humidity of 100% was recorded in the month of July 2002 and 2003. In October other soil factors like organic Carbon were 1.73% in 2001, 1.71% in 2002 and available Nitrogen were 386 $Kgha^{-1}$ in 2001 and 404 $Kgha^{-1}$ in 2002. In the month of January and February 2003, subsoil humidity was 81% and 80% respectively and subsoil temperature was 17°C and 20°C during that period. In May 2002, surface soil temperature, subsoil temperature, surface soil humidity and subsoil humidity was 37°C, 31°C, 64% and 70%, respectively. During the month of January other soil factors such as organic Carbon, available Nitrogen, available P_2O_5, available K_2O were 1.56%, 310 Kg ha^{-1}, 205 Kg ha^{-1} and 510 Kg ha^{-1}, respectively in 2002 and 1.42%, 342 Kg ha^{-1}, 195 Kg ha^{-1} and 660 Kg ha^{-1}, respectively in 2003 (Tab. 7). Mechanical analysis of soil samples showed maximum percentage of clay 32.07% (Tab. 1).

Table 1 : Mechanical analysis of soil in different sites (expressed in %)

Sampling site	Coarse sand	Medium sand	Fine sand	Coarse to Medium silt	Fine silt	Clay
Site I : DP	57.95	3.94	8.59	9.01	1.0	9.49
Site II : MD	1.0	2.0	1.57	32.03	31.31	32.07
Site III : BRF	4.36	2.45	20.47	33.59	21.66	17.43

Heavy Metals : Month wise mean concentration of heavy metals (Cd, Zn, Pb and Cu) obtained from soil samples have been shown in table 7, from which it would be evident that, in the month of August, September and October the concentration of heavy metals such as Cadmium, Zinc, Lead and Copper were comparatively low (0.7 ppm, 45 ppm, 22 ppm and 25 ppm, respectively in August 2001). While, in the month of May and June the concentration of all these metals were found to be high in this site (Cd 4 ppm, Zn 90 ppm, Pb 35 ppm and Cu 50 ppm in June 2003) (Tab. 7).

Earthworm Fauna : The earthworm fauna obtained from this site belonged to ten species under six genera. The species *Eutyphoeus incommodus* was the most dominant form and comprising 32.45% of the total population collected from this site. *Drawida papillifer papillifer* was the second largest comprising 31.16% of the total population collected from this site. The species *Eutyphoeus orientalis* contributed 20.1%, *Perionyx excavatus* contributed 4.3%, *Metaphire posthuma* contributed 2.96% and *Drawida nepalensis* contributed 2.63% (Tab. 8; Fig. 29). Populations of other species from this site were numerically low and highly irregular in distribution pattern. Number of earthworm obtained in each month showed maximum populations usually in October and second highest in the month of September in all of the studied year, when soil factors like relative humidity, organic Carbon, available Nitrogen and available P_2O_5 were all at higher levels; whereas heavy metals such as Cadmium, Zinc, Lead and Copper were minimum (Tab. 7; Figs. 30-37 and 38-41).

Seasonal Changes : The total populations of earthworm obtained from this site were maximum in October in each sampling year (Figs. 30-37). Seasonal changes of each species of earthworm obtained from this site revealed that, *Eutyphoeus incommodus* had September peak in all the year, second peak was in the month of October and third peak was in the month of July. This coincided with the higher amount of available N_2, available P_2O_5, subsoil humidity; optimum concentration of organic Carbon, subsoil temperature and lower concentration of heavy metals. Zero population was found in the month of January 2002 and in February 2003, this might be due to the lower subsoil temperature, subsoil humidity and higher concentration of heavy metals (Tab. 7). While, *Drawida papillifer papillifer* showed maximum peak in the month of October, second peak in November 2001. In the year 2002 the maximum peak was in the month of October, the second peak was in the month of November and there was a third peak in the month of January. In the year 2003 there was a distinct peak in the month of January; it reveals that it can tolerate lower subsoil temperature than any other studied species. Lowest population of this species was found in the month of May and June; this might be due to the lower organic Carbon, available N_2, subsoil humidity and higher concentration of heavy metals (Tab. 7). The species *Eutyphoeus orientalis* showed maximum peak in the month of July 2001 but in 2002 the peak shifted to August. This coincided with the higher subsoil humidity, higher content of available N_2 and lower concentration of heavy metals.

Zero population of this species was found in the month of January 2002, January to March 2003. This may be due to the lower subsoil temperature, subsoil humidity, organic Carbon and higher concentration of heavy metals. *Perionyx excavatus* was found maximum in the month of June 2003. *Metaphire posthuma* showed its peak in June to August 2003 while *Drawida nepalensis* in the month of October, November 2002 and January 2003. Other species showed variation in sampling years as well as during months, which is probably due to their irregular occurrence in this field (Tab. 7).

Microbial flora

Fungi : The soil fungi obtained from this site belonged to seven genera. The genus *Penicillium* sp. was the most dominant and 57.73% of the total population recorded from this site. The genus *Aspergillus* sp. contributed 20.83% and *Rhizopus* sp. contributed 6.69%. Populations of other genera recorded were numerically low and irregular in occurrence (Tab. 10; Fig. 42). The higher percentage representation of total fungi obtained in October 2001, 2002 and August 2003, coincided with the high population of earthworm fauna, maximum concentration of soil factors like relative humidity, organic Carbon and also low concentration of heavy metals (Tab. 9; Figs. 44-52 and 53-56).

Seasonal Changes : Fungi populations were maximum in the month of August in 2001, October in 2002 and again in the month of August in 2003 (Figs. 45-52). *Penicillum* sp. had peak in July 2001 and second peak in October 2002. *Aspergillus* sp. showing wide fluctuation had its highest peak in October 2001 and was numerically high during September 2002 and August 2003. The abundance of other genera varied among years as well as in months of observation in this field as evident from the Table 10. In May and June, absence of some genera and poor occurrence of the dominant forms resulted in minimum population density of total fungi community in this site.

Bacteria-Actinomycetes : The soil bacteria-actinomycetes obtained from this site belonged to seven genera. The genus *Streptomyces* sp. was the most dominant with 47.67% of the total population recorded from this site, followed by *Arthrobacter* sp. (20.46%) and *Bacillus* sp. (17.80%). In addition some other genera were also obtained from this study site, but, they were irregular and numerically very poor (Tab. 11; Fig. 43). A maximum of 8.73% population of bacteria-actinomycetes were recorded in the month of September 2002. The population was high when the concentration of soil relative humidity, organic Carbon, available nitrate and available phosphate was fairly high. The minimum population obtained in the month of January 2002, 2003 and February 2003, found to be coincided with that of lower population of earthworm and fungi as minimum content of soil relative humidity, organic Carbon and the high level of heavy metals in soil (Tab. 9; Figs. 44-52 and 53-56).

Seasonal Changes : Bacteria-actinomycetes population showed its peak in the month of September among all the sampling months (Figs. 45-52). The population of *Streptomyces* sp. showed its peak in October. Lowest population was found in January 2002 and February 2003. However, in remaining months it remained more or less high with slight fluctuation. Another dominant genus *Arthrobacter* sp. showing wide fluctuation, its population peaks were recorded in September 2001; in the month of July and September 2002 and in August 2003. The population of *Bacillus* sp. showed fluctuation with the highest peak in September 2002. The other genera also revealed irregular population peak due to their infrequent occurrence in this field. In February 2003, absence of some genera accompanied with low population of predominant genera resulted in the minimum population density of Bacteria-acinomycetes population (Tab. 11).

SITE – III - Bethuadahari Reserve Forest, Nadia (BRF)

Characteristics of sampling site : It is a man made forest, located at Bethuadahari, by the side of NH-34, about 138 Km North of Kolkata, in the district of Nadia, at the eastern part of West Bengal is being situated in the Gangetic plain (Map 1). Tropic of cancer runs across the middle of the district. Annual rainfall ranges from 77-84.70 cm. It included four sampling plots, each 100 metre square (approx.). Forest floor is covered with undergrowth. The litter of the forest floor contains the fallen leaves and dried twigs of the above trees and under growth. This site was severely hit by flood on 18 Sept 2000, flood continued for 15 days, which had an adverse effect on earthworm populations (Plate XVIII).

Vegetation : Plots were covered with the undergrowth of grasses and sedges like *Sporobolus diander, Dichanthium annulatum, Eragrostis brachyphylla, Digitaria marginata, D. royleana, Cynodon dactylon, Euphorbia hirta* and *Lantana camara*. The forest contains major tress like, *Shorea robusta, Tectona grandis, Dalbergia sisso, Ficus religiosa, Mangifera indica* and *Azadirachat indica*.

Soil Factors : Soil of these plots was Gangetic alluvium in nature, blackish brown in colour and sandy silt in texture. pH varied from 6.3 to 7.9 and electrical conductivity varied from 0.1 to 0.59 dSm^{-1} (Tab. 12). During August in each sampling year subsoil relative humidity in the soil was maximum 96% in 2001, 96% in 2002 and 95% in 2003 and subsoil temperature was at that time 27°C in 2001, 28°C in 2002 and 28°C in 2003, respectively. In August other soil factors like organic Carbon were 2.42% in 2001, 2.95% in 2002 and 3.07% in 2003 and available Nitrogen were 300 $Kgha^{-1}$ in 2001, 320 $Kgha^{-1}$ in 2002 and 369 $Kgha^{-1}$ in 2003. During January 2002 and February 2003, subsoil humidity was 75% and 82% and subsoil temperature was at that time 17°C and 20°C, respectively. In the month of May 2002, surface soil temperature, subsoil temperature, surface soil humidity and subsoil humidity was 36°C, 31°C, 64% and 70%, respectively. In January other soil factors such as organic Carbon, available Nitrogen, available P_2O_5 and available K_2O were 1.78%, 300 Kg ha^{-1}, 270 Kg ha^{-1} and 510 Kg ha^{-1}, respectively in 2002 and 2.1%, 320 Kg ha^{-1}, 200 Kg ha^{-1}, 460 Kg ha^{-1}, respectively in 2003 (Tab. 12). Mechanical analysis of soil samples showed maximum percentage of coarse to medium silt 33.59% and more or less equal percentage of fine sand and fine silt (Tab. 1).

Heavy Metals : Month wise mean concentration of heavy metals (Cd, Zn, Pb and Cu) obtained from soil samples have been shown in Table 12, from which it would be evident that, in the month of July, August and September the concentration of heavy metals such as Cadmium, Zinc, Lead and Copper were comparatively low (0.5 ppm, 48 ppm, 26 ppm and 14 ppm, respectively in July 2003). While, in the month of May and June the concentration of all these metals were found to be high in this site (Cd 3 ppm, Zn 132 ppm, Pb 38 ppm and Cu 42 ppm in May 2003) (Tab. 12).

Earthworm Fauna : The earthworm fauna obtained from this site belonged to ten species under seven genera. The species *Lampito mauritii* was the most dominant and comprising 40.69% of the total population collected from this site. Second largest was the *Eutyphoeus orientalis* comprising 16.4% of the total population collected from this site. *Perionyx excavatus* contributed 15.9%, *Metaphire posthuma* contributed 14.2% and *Drawida nepalensis* contributed 6.13%. Populations of other species from this site were numerically low and highly irregular in distribution pattern (Tab. 13; Fig. 57). Number of earthworm obtained was found to be maximum in the month of August in all of the studied year and second highest in the month of October in 2001, in the month of September in 2002 and in the month of July in 2003; when soil factors like subsoil humidity, organic Carbon, available Nitrogen were all at higher levels; whereas heavy metals such as Cadmium, Zinc, Lead and Copper were minimum (Tab. 12; Figs. 58-65 and 66-69).

Seasonal Changes : The total populations of earthworm obtained from this site were maximum in August in each sampling year (Figs. 58-65). Seasonal changes of each species of earthworm obtained from this site revealed that, *Lampito mauritii* had August peak in all the year, which coincided with the higher concentration of soil factors like subsoil humidity, organic Carbon, available Nitrogen and optimum temperature; second peak was in September, third peak was in October. Zero population was found in the month of June 2001; in the month of January, April, May in 2002 and February to May in 2003; this might be due to the lower humidity, available K_2O, organic Carbon and higher concentration of heavy metals (Tab. 12). *Eutyphoeus orientalis* had October peak in 2001 but peak shifted to June in the year 2002. There was also a second peak in the month of October 2002. In the year 2003, this species showed its maximum population in the month of July, second peak in the month of June. This coincided with the optimum subsoil temperature, higher subsoil humidity, organic Carbon and lower concentration of heavy metals. Zero population was found in the month of November and December 2001, January 2002 and January to March 2003. This might be due to the lower subsoil temperature, humidity, available P_2O_5 and higher concentration of heavy metals (Tab. 12). *Perionyx excavatus* showed maximum peak in January 2002 but in 2003 the peak shifted to March. No species was found in August to December 2001, September to December 2002, January and July 2003. Population peak was observed when level of heavy metals in soil was in higher side and probably it has the capability to resist some toxic effect of heavy metals. *Metaphire posthuma* showed its peak in September in all the studied year, second peak was in October in 2001 and in August in 2002 and there was a distinct peak in July 2003, which coincided with the higher subsoil humidity, optimum subsoil temperature and lower concentration of heavy metals. Zero population of this species was found in December 2001, January and December 2002, January, February and May 2003. This may be due to the lower subsoil humidity and higher concentration of heavy metals. Other species showed variation in sampling years as well as during months, which is probably due to their irregular occurrence in this field (Tab. 12).

Microbial flora

Fungi : The soil fungi obtained from this site belonged to nine genera. The genus *Penicillium* sp. was the most dominant and 60.43% of the total population recorded from this site. The genus *Aspergillus* sp. contributed 15.68% and *Rhizopus* sp. contributed 7.19%. Populations of other genera recorded was numerically low and irregular in occurrence (Tab. 15; Fig. 70). The maximum percentage representation of total fungi, which obtained in August of all the studied years, coincided with the higher population of earthworm fauna, maximum concentration of soil factors like relative humidity, organic Carbon and also low concentration of heavy metals (Tab. 14; Figs. 72-80 and 81-84).

Seasonal Changes : Fungi populations were maximum in the month of August in all the studied year (Figs. 73-80). *Penicillum* sp. had its peak in August 2001, second peak in July 2002 and third peak in August 2003. *Aspergillus* sp. had its highest peak in August 2001 and was numerically high during September 2002. The abundance of other genera varied among years as well as in months of observation due to their irregular occurrence in this field that is evident from Table 15. In May, absence of some genera and poor occurrence of the dominant forms resulted in minimum population density of total fungi community in this site.

Bacteria-Actinomycetes : The soil bacteria-actinomycetes obtained from this site belonged to 8 genera. The genus *Streptomyces* sp. was the most dominant with 39.26% of the total population recorded from this site, followed by *Bacillus* sp. (23.90%) and *Micrococcus* sp. (17.53%). In addition some other genera were also obtained from this study site, but, they were irregular and numerically very poor (Tab. 16; Fig. 71). A maximum of 6.29% population of bacteria-actinomycetes were recorded in the month of July 2003 and 5.87% in both July 2001 and August 2003. The population was high when the concentration of soil relative humidity, organic Carbon was fairly high. The minimum population obtained in the month of May in each year, found to be coincided with that of lower population of earthworm and fungi as low content of soil relative humidity, organic Carbon and the high level of heavy metals in soil (Tab. 14; Figs. 72-80 and 81-84).

Seasonal Changes : Bacteria-actinomycetes population showed its peak in the month of July in 2001, August in 2002 and again in July in 2003. The genus *Streptomyces* sp. showed more or less gradual trend in fluctuation throughout the study period with the highest peak in August 2003. The population of *Bacillus* sp. exhibits wide fluctuations became very best in April 2002. The population of *Micrococcus* sp., both I and II, during the months of observation exhibited fluctuations. The highest peak of *Micrococcus* I was in September 2001 and June 2003. *Micrococcus* II, in comparison to *Micrococcus* I, was showing less fluctuation. The population density and the trend of fluctuation of the other genera were found to be numerically very low and irregular. In May, absence of some genera and poor occurrence of the dominant forms resulted in minimum population density of total bacteria-actinomycetes communities in this site (Tab. 16).

STATISTICAL ANALYSIS OF DATA

The statistical analysis of the complex soil earthworm and microbial communities has been conducted to show the relationship between the soil factors, heavy metals, microorganisms and earthworms. The application of linear correlation, anova and step wise regression were undertaken in the present study involving the data of soil factors, heavy metals, microbial and earthworm population densities separately for each site. All the analysis has been carried out by BMDP Statistical Software, Inc. in Indian Statistical Institute, Kolkata.

Linear correlation

The correlation coefficient ('r' value) of each variable (*i.e.* total and predominant earthworm, total fungi, total bacteria-actinomycetes, different soil factors and four heavy metals) on each other in individual site was shown in Tables 17-20.

Site I / DP

The correlation coefficient data ('r' value) mentioned in the Table 17 indicated that in Municipal wastes disposal site the edaphic factors like upper surface temperature, subsoil temperature, upper surface relative humidity, subsoil relative humidity, pH and available P_2O_5 showed strong positive significant correlation, but heavy metals like Zinc, Lead showed strong negative significant correlation with *Lampito mauritii* in waste disposal site. Organic Carbon showed significant positive correlation with *Metaphire* *posthuma* in this site. Among the abiotic factors organic Carbon showed significant positive correlation with available P_2O_5 but significant negative correlation with Zinc. Except Cadmium, all the studied heavy metals showed significant negative correlations with soil temperature and relative humidity but lead fails to show any significant relationship with soil relative humidity. Electrical conductivity showed significant positive correlation with Zinc and Lead.

From Table 20 it has been found that in Site I earthworm population shows significant positive correlations with fungi and bacteria-actinomycetes population as well as with surface and subsoil temperature, surface and subsoil relative humidity, soil pH, available P_2O_5 and available K_2O, but shows significant negative correlations with Zinc and Copper. Fungi population shows significant positive correlations with bacteria-actinomycetes population as well as with surface and subsoil relative humidity and available K_2O. Bacteria-actinomycetes population shows significant positive correlations with surface and subsoil relative humidity and available K_2O.

Site II / MD

The correlation coefficient data ('r' value) mentioned in the Table 18 indicated that in uncultivated field *Metaphire posthuma*, *Eutyphoeus orientalis* and *Eutyphoeus incommodus* shows significant positive correlation with subsoil relative humidity. Upper surface temperature showed significant positive correlation with *Eutyphoeus orientalis* and *Perionyx simlaensis*, but significant negative correlation found with *Drawida nepalensis* and *Drawida papillifer papillifer*. Subsoil temperature and upper surface relative humidity showed significant positive correlation with *Eutyphoeus orientalis* and *Eutyphoeus incommodus* but subsoil temperature shows significant negative correlation with *Drawida nepalensis* and *Drawida papillifer papillifer*. Organic Carbon shows significant positive correlations with *Drawida nepalensis*, *Perionyx simlaensis*, *Polypheretima elongata* and *Drawida papillifer papillifer* but significant negative correlation found with *Metaphire posthuma* and *Perionyx excavatus*. Except *Perionyx excavatus* and *Perionyx simlaensis*, *Eutyphoeus orientalis*, *Eutyphoeus incommodus*, *Polypheretima elongata* and *Metaphire houlleti* shows significant negative correlation with Cadmium. *Perionyx excavatus* and *Perionyx simlaensis* shows significant positive correlations but *Eutyphoeus incommodus*, *Polypheretima elongata* and *Metaphire houlleti* shows significant negative correlations with Zinc. *Drawida nepalensis*, *Polypheretima elongata*, *Metaphire houlleti*, *Octochaetona surensis*, *Drawida papillifer papillifer* all shows significant negative correlations with soil Lead content except *Perionyx excavatus* and *Perionyx simlaensis*. Only *Eutyphoeus orientalis* shows significant negative correlations but *Perionyx excavatus* and *Perionyx simlaensis* shows significant positive correlations with soil Copper content. Except *Perionyx excavatus* and *Perionyx simlaensis*, *Drawida nepalensis*, *Polypheretima elongata*, *Metaphire houlleti*,

Octochaetona surensis, ***Drawida papillifer papillifer*** all shows significant positive correlations with nitrate. Only *Eutyphoeus incommodus* shows significant positive correlations with phosphate. *Drawida nepalensis* and *Drawida papillifer papillifer* shows significant positive correlations with available K_2O but *Eutyphoeus orientalis* shows significant negative correlations. All the studied heavy metals shows significant negative correlations with organic Carbon. Except copper all the studied heavy metals shows significant negative correlations with pH. Organic Carbon shows positive correlations with nitrate. Cadmium, Zinc contents shows significant negative correlations with soil humidity, both soil surface and subsoil.

In Site II earthworm population shows significant positive correlations with fungi and bacteria-actinomycetes population as well as with subsoil relative humidity and available Nitrogen but shows significant negative correlations with all four studied heavy metals *i.e.* Cadmium, Zinc, Lead and Copper and also with soil electrical conductivity. Fungi population shows significant positive correlations with bacteria-actinomycetes population as well as with surface and subsoil relative humidity, soil pH, available Nitrogen and available P_2O_5 but shows significant negative correlations with all four studied heavy metals and also with soil electrical conductivity and available K_2O. Bacteria-actinomycetes population shows significant positive correlations with surface and subsoil relative humidity, surface and subsoil temperature, but shows significant negative correlations with all four studied heavy metals and also with soil electrical conductivity and available K_2O (Table 20).

Site III / BRF

The correlation coefficient data ('r' value) mentioned in the Table 19 indicates that in Reserve forest only *Eutyphoeus orientalis* shows significant positive correlations with surface temperature. *Metaphire posthuma* and *Eutyphoeus orientalis* shows significant positive correlations with subsoil temperature. *Lampito mauritii, Metaphire posthuma, Eutyphoeus orientalis, Eutyphoeus nicholsoni, Eutyphoeus incommodus* all shows significant positive correlations with surface and subsoil humidity. *Octochaetona beatrix* shows significant positive correlations with surface humidity. Only *Eutyphoeus nicholsoni* shows significant positive correlations with soil pH. Organic Carbon shows significant positive correlations with *Lampito mauritii, Metaphire posthuma, Eutyphoeus nicholsoni, Metaphire houlleti, Octochaetona beatrix. Metaphire houlleti* and *Octochaetona beatrix* shows significant positive correlations with nitrate. *Eutyphoeus nicholsoni* and *Eutyphoeus incommodus* shows significant positive correlations with available K_2O. Cadmium shows significant negative correlations with *Lampito mauritii, Metaphire posthuma, Eutyphoeus orientalis, Octochaetona beatrix* and *Amynthas corticis.* Zinc shows significant negative correlations with *Lampito mauritii, Metaphire posthuma, Metaphire houlleti, Octochaetona beatrix.* Lead shows significant negative correlations with *Lampito mauritii* and *Eutyphoeus orientalis*. Copper shows significant negative correlations with *Lampito mauritii, Metaphire posthuma, Metaphire houlleti*. All the studied heavy metals shows significant negative correlations with both soil surface and subsoil humidity. All the studied heavy metals shows significant negative correlations with organic Carbon. Available P_2O_5 shows significant negative correlations with organic Carbon, but available K_2O shows significant positive correlations.

In Site III earthworm population shows significant positive correlations with fungi and bacteria-actinomycetes population as well as with surface and subsoil relative humidity, soil organic Carbon and available K_2O, but shows significant negative correlations with all four studied heavy metals. Fungi population shows significant positive correlations with bacteria-actinomycetes population as well as with surface and subsoil relative humidity, organic Carbon, available Nitrogen but shows significant negative correlations with all four studied heavy metals. Bacteria-actinomycetes population shows significant positive correlations with surface and subsoil relative humidity, organic Carbon, available Nitrogen and available K_2O, but shows significant negative correlations with all four studied heavy metals and with available P_2O_5 (Table 20).

Analysis of variance

An univariate analysis of variant with the month and locality as a factor have been carried out to find out whether any significant seasonal fluctuation as well as site wise fluctuation exists or not in the population of total and individual species of earthworm, total and individual genera of fungi, total and individual genera of bacteria-actinomycetes, different soil abiotic factors and heavy metals. The results of analysis are represented in the Tables 21-25. From the Tables 21a-21o, it is evident that site wise fluctuation of earthworm population as well as different species namely, *Lampito mauritii, Metaphire posthuma, Perionyx excavatus, Eutyphoeus orientalis, Eutyphoeus incommodus, Drawida nepalensis* and *Metaphire houlleti* were significant. In the fungal community site wise significant fluctuation were shown by fungal population and different genera of fungi *viz. Penicillium* sp., *Aspergillus* sp., *Fusarium* sp., *Trichoderma* sp. and *Cladosporium* sp. (Tables 22a-22k). From the Tables 23a-23n, it is evident that site wise fluctuation of bacteria-actinomyetes population as well as individual genera *viz. Streptomyces* sp., *Micrococcus* I, *Micrococcus* II, *Arthrobacter* sp., *Pseudomonas* sp., *Promicromonospora* sp., *Azotobacter* sp. was significant. Site wise significant fluctuation was shown by upper surface and subsoil temperature, pH, electrical conductivity, organic Carbon, available Nitrogen and available K_2O and all the four studied heavy metals (Tables 24 and 25).

From the Tables 21a-21o, it is evident that except *Eutyphoeus nicholsoni, Drawida nepalensis, Amynthas corticis* and *Octochaetona beatrix* all other earthworm species as well as earthworm population shows significant seasonal fluctuation. In the fungal community significant seasonal fluctuation were shown by fungi population and different genera of fungi except *Cephalosporium* sp. and *Sclerotium* sp. (Tables 22a-22k). Except *Arthrobacter* sp., *E. coli*, *Azotobacter* sp. and *Nocardia* sp. all other bacteria-actinomycetes genera as well as bacteria-actinomycetes population shows significant seasonal fluctuation (Tables 23a-23n). All the studied abiotic factors and heavy metals showed significant seasonal fluctuation (Tables 24 and 25).

Step Regression Analysis

To determine the effects of soil factors on the earthworm community usually the linear regression technique is followed. But, in that case, the factors are assumed to be independent, which is rather inapplicable. Therefore, Stepwise Linear Regression analysis was carried out, with the inclusion of a new factor already considered at every stage. However, there is no a *priori* theory about which factor or factors (biotic/abiotic) are most important. The steps were not been repeated until all the factors were included in the model. In this study, the predominant species of earthworm in a given site were considered as dependable variables and the observations of analysis were continued till the factors considered the improvement value up to 1% level. The results of tests are showed in the Tables 26a-26i.

Table 26a showed that effects of only *Lampito mauritii* and *Perionyx excavatus* were most important on the total population of earthworm in Site I. In Site II *Micrococcus* I, *Metaphire houlleti*, *Eutyphoeus incommodus*, *Drawida nepalensis*, *Eutyphoeus orientalis*, *Drawida papillifer papillifer*, *Perionyx excavatus*, *Metaphire posthuma*, *Polypheretima elongata*, *Perionyx simlaensis* were dominant on total population of earthworm whereas in Site III, the total population of earthworm were governed by *Lampito mauritii*, *Eutyphoeus incommodus*, *Perionyx excavatus*, *Eutyphoeus orientalis*, *Drawida nepalensis*, *Metaphire posthuma*, *Eutyphoeus nicholsoni*, *Octochaetona beatrix*, humidity (upper surface), *Metaphire houlleti*.

Table 26b showed that effects of the total earthworm population and *Perionyx excavatus* were most important on the population density of the most dominant species *Lampito mauritii* in Site I. In Site III ten factors namely total earthworm population, *Perionyx excavatus*, *Eutyphoeus incommodus*, *Eutyphoeus orientalis*, *Drawida nepalensis*, *Metaphire posthuma*, *Eutyphoeus nicholsoni*, *Octochaetona beatrix*, humidity (upper surface), *Metaphire houlleti* found to have important impact on the population density of *Lampito mauritii*.

The abundance of *Metaphire posthuma* was governed by twenty-one factors namely organic Carbon, Cd, electrical conductivity, *Rhizopus* sp., *Micrococcus* I, *Lampito mauritii*, total population of earthworm, *Flavobacterium* sp., Available P_2O_5, *Arthrobacter* sp., humidity (subsoil), Cu, *Aspergillus* sp., *Cephalosporium* sp., *Streptomyces* sp., Zn, *Pseudomonas* sp, *Mucor* sp., available K_2O, temperature (subsoil), *Fusarium* sp. in Site I, but in Site II, it is governed by twenty-two factors namely, humidity (subsoil), Pb, *Rhizopus* sp., Cd, *Eutyphoeus orientalis*, *Streptomyces* sp., *Micrococcus* I, *Perionyx simlaensis*, *Octochaetona surensis*, *Pseudomonas* sp., *Fusarium* sp., *Aspergillus* sp., pH, *Perionyx excavatus*, total earthworm population, *Metaphire houlleti*, available P_2O_5, Zn, available K_2O, *Polypheretima elongata*, electrical conductivity, *Penicillium* sp. In Site III it is governed by twenty-three factors namely, total earthworm population, *Eutyphoeus nicholsoni*, *Curvularia* sp., *Octochaetona beatrix*, *Penicillium* sp., organic Carbon, *Aspergillus* sp., pH, *Fusarium* sp., electrical conductivity, *Rhizopus* sp., available N_2, *Lampito mauritii*, *Perionyx excavatus*, *Bacillus* sp., *humidity* (subsoil), *Trichoderma* sp., available P_2O_5, temperature (subsoil), *Metaphire houlleti*, Pb, total bacteria-actinomycetes genera, *Pseudomonas* sp. (Table 26c).

Table 26d showed that effect of the following twenty-four factors namely, subsoil relative humidity, *Micrococcus* II, available nitrate, pH, *E. coli*, *Penicillium* sp., Total fungi genera, surface soil relative humidity, Zinc, organic Carbon, *Fusarium* sp., Pb, *Aspergillus* sp., *Metaphire posthuma*, *Lampito mauritii*, electrical conductivity, *Streptomyces* sp., *Bacillus* sp., *Promicromonospora* sp., surface soil temperature, *Enterobacter* sp., *Mucor* sp., available K_2O, subsoil temperature were most important on the population density of *Perionyx excavatus* in Site I, but, in Site II, twenty-four factors namely, *Perionyx simlaensis*, *Pseudomonas* sp., *Drawida papillifer papillifer*, *Aspergillus* sp., *Azotobacter* sp., Zn, *Octochaetona surensis*, total bacteria-actinomycetes genera, available P_2O_5, *Fusarium* sp., *Mucor* sp., *Metaphire posthuma*, *Eutyphoeus orientalis*, *Micrococcus* I, *Eutyphoeus incommodus*, available N_2, humidity (upper surface), humidity (subsoil), electrical conductivity, *Rhizopus* sp., temperature (subsoil), *Streptomyces* sp., total fungi genera, organic Carbon have impact on the population, in Site III, twenty-one factors namely, Cu, humidity (upper surface), *Rhizopus* sp., available K_2O, *Aspergillus* sp., *Metaphire posthuma*, *Eutyphoeus incommodus*, *Octochaetona beatrix*, total earthworm population, *Lampito mauritii*, temperature (upper surface), *Drawida nepalensis*, *Eutyphoeus orientalis*, *Metaphire houlleti*, *Arthrobacter* sp., humidity (subsoil), *Sclerotium* sp., *Mucor* sp., *Trichoderma* sp., *Azotobacter* sp., *Pseudomonas* sp. found to have impact on the population.

In Site II the population of *Eutyphoeus orientalis* was governed by twenty-two factors namely humidity (subsoil), total bacteria-actinomycetes genera, available K_2O, *Mucor* sp., *Trichoderma* sp., Pb, *Metaphire houlleti*, total earthworm population, temperature (upper surface), *Eutyphoeus incommodus*, *Drawida papillifer papillifer*, *Metaphire posthuma*, *Azotobacter* sp., *Nocardia* sp., *Perionyx excavatus*, *Aspergillus* sp., *Fusarium* sp., available N_2, *Streptomyces* sp., total fungi genera, available P_2O_5, Cu but in Site III it is controlled by twenty factors namely, total earthworm population, temperature (subsoil), *Amynthas corticis*, available P_2O_5; organic Carbon, available K_2O, pH, *Perionyx excavatus*, electrical conductivity, *Drawida nepalensis, Lampito mauritii, Trichoderma* sp., *Aspergillus* sp., *Mucor* sp., *Metaphire posthuma*, temperature (upper surface), *Fusarium* sp., total fungi genera, Pb, *Azotobacter* sp. (Table 26e). From Table 26f it has been found that population of *Eutyphoeus incommodus* was controlled by twenty-three factors namely, total earthworm population, *Drawida papillifer papillifer, Eutyphoeus orientalis, Perionyx excavatus, Drawida nepalensis, Polypheretima elongata, Metaphire posthuma, Pseudomonas* sp., *Metaphire houlleti*, total fungi genera, *Octochaetona surensis, Aspergillus* sp., *Rhizopus* sp., *Nocardia* sp., *Streptomyces* sp., *Trichoderma* sp., *Fusarium* sp., *Mucor* sp., organic Carbon, Pb, temperature (upper surface), electrical conductivity, *Azotobacter* sp., in Site II. But, in Site III it was controlled by twenty-two factors namely, *Eutyphoeus nicholsoni, Metaphire houlleti, Metaphire posthuma, Amynthas corticis, Sclerotium* sp., *Fusarium* sp., *Arthrobacter* sp., Cu, *Azotobacter* sp., *Micrococcus* II, *Perionyx excavatus, Rhizopus* sp., *Aspergillus* sp., *Curvularia* sp., Available N_2, pH, *Micrococcus* I, *Streptomyces* sp., humidity (subsoil), *Eutyphoeus orientalis, Promicromonospora* sp., total bacteria-actinomycetes genera. Table 26g showed that effect of the following twenty-three factors namely *Drawida papillifer papillifer*, available P_2O_5, surface soil temperature, *Trichoderma* sp., Cadmium, electrical conductivity, *Penicillium* sp., humidity (upper surface), *Streptomyces* sp., Cu, temperature (subsoil), *Rhizopus* sp., available N_2, *Perionyx simlaensis, Metaphire houlleti, Azotobacter* sp., *Fusarium* sp., *Polypheretima elongata, Metaphire posthuma, Nocardia* sp., pH, *Bacillus* sp., *Eutyphoeus orientalis* were most important on the population density of *Drawida nepalensis* in Site II, but, in Site III, it was governed by twenty-one factors namely, *Eutyphoeus nicholsoni, Amynthas corticis*, temperature (subsoil), *Perionyx excavatus*, available K_2O, electrical conductivity, total earthworm population, *Curvularia* sp., *Metaphire posthuma, Lampito mauritii, Mucor* sp., pH, *Sclerotium* sp., *Streptomyces* sp., *Octochaetona beatrix*, available N_2, *Fusarium* sp., total bacteria-actinomycetes genera, *Micrococcus* II, *Trichoderma* sp., temperature (upper surface). The abundance of *Polypheretima elongata* was governed by twenty-one factors namely, *Metaphire houlleti*, electrical conductivity, cadmium, *Streptomyces* sp., *Pseudomonas* sp., humidity (upper surface), pH, *Nocardia* sp., Cu, *Fusarium* sp., *Perionyx excavatus, Micrococcus* I, *Drawida papillifer papillifer, Drawida nepalensis*, organic Carbon, *Bacillus* sp., total bacteria-actinomycetes genera, Zn, humidity (subsoil), *Mucor* sp., temperature (subsoil) (Table 26h).

From Table 26i it has been found that population of *Drawida papillifer papillifer* was controlled by twenty-three factors namely, *Drawida nepalensis, Polypheretima* *elongata*, temperature (subsoil), *Azotobacter* sp., *Metaphire posthuma*, organic Carbon, *Fusarium* sp., *Perionyx excavatus*, Zn, Cd, available P_2O_5, available N_2, electrical conductivity, total fungi genera, *Perionyx simlaensis*, *Trichoderma* sp., temperature (upper surface), Pb, total bacteria-actinomycetes genera, *Pseudomonas* sp., *Penicillium* sp., *Octochaetona surensis*, available K_2O.

DISCUSSION

The present studies were based on the sample survey of twelve plots from three contrast ecological habitats of West Bengal over a period of twenty-five months (June 2001 to August 2003). Among the plots sampled, four had polluted environment, four were from an uncultivated field and remaining four were from the forest floor that was affected by flood in the year 2001. All the plots under study were in the Gangetic plain exposed to tropical climate with high humidity and high temperature; both of which were comparatively low during winter months. The general nature of soil in all the plots was more or less identical.

The surface soil of the plots in general contained good vegetational cover except wastes disposal site.

The earthworm fauna obtained here belonged to eight genera under three families *viz.* Megascolicidae, Octochaetidae and Moniligastridae (Plates I-XIV). However, all the Indian earthworm species belonged to ten families (Julka, 1988). As mentioned earlier, some forms differed in their abundance from one site to other and from season to season. Moreover, the number of genera occurring in the different sampling sites also varied, maximum being extracted from the Reserve forest, ten species under seven genera and minimum from the Wastes disposal site, three species under three genera (Tables 3 and 13). Of the eight genera encountered in this study the predominant were *Lampito* (one species), *Eutyphoeus* (three species), *Drawida, Metaphire, Perionyx* (each with two species), *Polypheretima* (one species), *Octochaetona* (two species) and *Amynthus* (one species) in order of dominance (Tab. 27, Fig. 85). The genus *Lampito*, consisting of single species, *L. mauritii*, was found only in two sampling sites, except Site II, comprising of 48.03% of total earthworm population (Table 27, Fig. 86) and being numerically dominant over other forms. In Site I the species comprises over 90% of the total earthworm population (Fig. 1). This might be due to the existences of favourable microclimatic conditions requiring for this species. This genus exhibited its peak population in the month of August; another medium peak was in September (Tab. 28, Fig. 86). The species was not found in Site II might be due to presence of high percentage of clay content which causes less porosity and aeration in soil (Tab. 1). As it is an anecic species higher clay content might have poised problem to make vertical burrow. Similar observation was also made by Piearce (1978) and Muys *et al.* (1992) in case of deep burrowing anecic species *Lumbricus terrestris*. Ismail and Murthy (1985) found that *L. mauritii* prefers sandy loam soil. Hernández *et al.* (2003) also found that *Aporrectodea trapezoids* were abundant in places with high porosity and aeration. Gonzâlez *et al.* (1999) observed that the composition of plant species could influence the distribution of earthworm in wet tropical forests.

The second dominant genus *Eutyphoeus* was represented by three species and comprising of 23.99% of total earthworm population, being found in two sites except wastes disposal site. Among this genus, the species *E. incommodus* was the most dominant and comprising of 12.56% of total earthworm population (Tab. 27, Fig. 85). This species was most abundant in the uncultivated field (Site II) and comprising of 32.45% of the total earthworm fauna collected from this site. This species showed its peak population in September and followed by October (Tab. 28, Fig. 86). In order of dominance *Eutyphoeus orientalis* occupies second position consisting of 16.4% of the earthworm fauna collected from Reserve forest (Site III) and 20.1% from uncultivated field (Site II), being maximum in June-July in Site III and July-August in Site II (Tables 27 and 28, Figs. 85 and 86). The third species belonging to this genus was *Eutyphoeus nicholsoni*, found only in Reserve forest floor being numerically very poor and showed its peak in August (Tables 27 and 28, Figs. 85 and 86).

The third dominant genus was *Drawida* comprising 13.93% of total earthworm population, represented by two species and occurred in two sites, which was not found in wastes disposal site. The species *D. papillifer papillifer* was the most dominant taxon under this genus, comprising of 11.69% of total earthworm population, found only in Site II and recorded for the first time from West Bengal (Tab. 27, Fig. 85). The population of this species comprising of 31.16% and was the second dominant species collected from Site II. The species found maximum in number in October and November and other peak population in January 2003 (Tab. 28, Fig. 86). The species *D. nepalensis* obtained under this genus was found to occur in both reserve forest area and uncultivated field. In Site II peak population was found in October-November and January. In forest floor site the maximum population was in August-September and another peak was in January (Tables 27 and 28, Figs. 85 and 86).

The fourth dominant genus *Metaphire* was found in all the studied sites comprising of 6.22% of total earthworm population (Tab. 27, Fig. 85). The species *M. posthuma* was the most dominant among this genus and comprising of 5.44% of the total earthworm population and distributed in all the sites. The population was maximum in August-September and other small peak was found in June and October (Tab. 27, Fig. 86). The species *M. houlletii* belonging to this genus was found in both forest floors as well as in uncultivated field and present numerically very low. The maximum population of this species were in the month of October from the uncultivated field. In forest floor the population was maximum in July-August (Tables 27 and 28, Figs. 85 and 86).

The fifth dominant genus was *Perionyx* occurred in all the sites and comprising of 6.09% of total earthworm population. Two species were found under this genus namely *P. excavatus* and *P. simlaensis*, of which *P. simlaensis* was found only in uncultivated field and also recorded for the first time from West Bengal, comprising of 0.36% of total earthworm population (Tab. 27, Fig. 85). The species *P. excavatus* was found in all the sites comprising of 5.73% of total number of earthworm collected (Tab. 27, Fig. 85). The population was maximum in April-May in Site I, March and June in Site II, January and March in Site III (Tab. 28, Fig. 86).

The genus *Polypheretima* was represented by single species namely *P. elongata*, found only in uncultivated field (Site II), comprising of 0.84% of total earthworm population. The peak population was in October (Tables 27 and 28, Figs. 85 and 86).

The genus *Octochaetona* was represented by two species namely *O. surensis* and *O. beatrix* and comprising of 0.72% of total earthworm population. *O. surensis* found only in uncultivated field. It is interesting to note that this species was recorded for the first time from West Bengal. The population of this species was very low comprising of 0.52% of total earthworm population. The peak population was in September. The population of *O. beatrix* was also very low and comprising of 0.20% of total earthworm population, found only from forest floor and population was maximum in August (Tables 27 and 28, Figs. 85 and 86).

The genus *Amynthas* was represented by single species *A. corticis* and found only in forest floor. The number of occurrence of this species was very poor and found in the month of August and September (Tables 27 and 28, Figs. 85 and 86).

The quantitative and qualitative variations of earthworm population from one site to other and also from one month to another month might be due to the differences in vegetations and microclimatic conditions of the studied area. Some earthworm genera were occurring regularly in different sampling sites, they could tolerate wide range of habitats and aptly called "ubiquitous" or "ecological generalists groups"; on the other hand, some species were restricted to a particular ecological condition and they were accordingly termed as "stenoecious" or "ecological specialists groups"

The seven species of earthworms namely *Lampito mauritii, Metaphire posthuma, Perionyx excavatus, Eutyphoeus orientalis, Eutyphoeus incommodus, Drawida nepalensis, Metaphire houlleti* seemed to have wider tolerance for various habitats in the present study, therefore, they were "ubiquitous" (Tab. 29). While other seven species of earthworms were found to be restricted to any single site of three contrasting habitats namely, *Eutyphoeus nicholsoni, Perionyx simlaensis, Polypheretima elongata, Amynthas corticis, Octochaetona beatrix, Octochaetona surensis, Drawida papillifer papillifer* and as such they were "stenoecious" (Tab. 29). Chaudhuri and Bhattacharjee (1999) while working with earthworm resources of Tripura found seventeen species in three different habitats. Bano and Kale (1991), while studying earthworm fauna of Southern Karnataka, obtained forty-four species in three different habitats, among them four species were found to be ubiquitous. According to Julka and Paliwal (1986) Indo-Ganga plain have pauper fauna, majority of the genera have endemicity in the Deccan Peninsula.

The species diversity of the earthworm community at a given locality is influenced by the characteristics of the soil, climate and organic resources of the locality, as well as its history of land use and soil disturbance (Edwards and Bohlen, 1996). The earthworm communities of the tropical rainforests contained from four to fourteen species and had a mean species richness 6.5±1.3 species (Lee, 1985). The distribution pattern of various species of earthworm and their numerical importance in total earthworm fauna expressed in terms of relative density. The results thus obtained are presented in the Table 27 and Figure 86. Kale (1993) opined that as soil moisture and available organic matter are important limiting factors for their distribution, species diversity is more in heavy rainfall areas with large plantations and forests than in the plains with dry farm lands which experience unpredictable and poor rainfall.

The population of earthworm fauna obtained from all the sampling sites in the present study showed numerically variation with the change of season (Figs. 2-9, 30-37 and 58-65). It was minimum in January in Site I, May-June in Site II and December in Site III. A low summer and winter population of earthworm agreed with the general experience of this group as reported from different types of habitat of India by several workers. Senapati and Sahu (1993) opined that too dry and too cold or too warm soil is unfavourable for soft bodied poikilotherms like earthworms which are devoid of any exoskeletal protective cover. Evans and Guild (1947), Satchell (1967) and Reynolds (1972) also recorded the earthworm density pattern in direct proportion to soil moisture. A remarkable variation observed in their maximum population. Highest population observed during monsoon (August) in Site I and III and in Site II it was observed during post monsoon season *i.e.* in October (Figs. 2-9, 30-37 and 58-65). Soil temperature and soil moisture considered to affect seasonal fluctuations in the population density of earthworms (Edwards and Lofty, 1977). Gates (1961), Dash and Patra (1977) and Dash and Senapati (1980) reported that earthworms were mainly active during the summer rains between May and October in the tropical climate of Burma and subtropical climate of India. Chauhan (1980) observed that the worm's population was very much affected in March, April and May of summer and December in winter. Kaleemurrahman and Ismail (1981) correlates increase in biomass with increase in moisture content of soil. Darlong and Alfred (1991) observed that the number and biomass of different species of earthworms fluctuated seasonally, with an increase in the monsoon or rainy season (April-October) and a decrease in the dry winter season (November-March). Nakamura (1968 a, b) also have the similar observations in grassland in Japan, the greatest numbers of earthworms occurred in autumn, especially in October and the numbers were very low in winter, particularly during January and February. The seasonal dynamics over an annual cycle have shown that the earthworm populations and biomass were high in the rainy and early winter season and low in summer (Bhadauria and Ramakrishnan, 1989).

In this study the population densities of earthworm fauna collected from waste disposal site was maximum (42.06%), followed by the uncultivated field (37.53%) and forest site (20.40%) (Fig. 87). Comparatively poor populations in forest floor may be due to the effect of flood in the year 2001. As Site I is a polluted environment so species diversity is very poor, only three earthworm species obtained but total number of earthworms was very high. Organic residues were left on soil surface reducing the moisture loss and providing relatively continuous substrate for decomposers; organic matter input is more gradual as in nutrient release. In Site I higher amount of organic carbon, optimal condition of temperature and moisture probably provides a more favourable environment for earthworm populations. Plots with organic manure are known to support higher populations of earthworms (Satchell, 1955) as food supply appears to be the major factor for earthworm distribution (Abbott and Parker, 1980). Senapati and Sahu (1993) observed a maximum number of five species occur in natural grassland whereas in man interfered grassland and crop field one to three species has been reported in different agroecosystems of Orissa.

Population fluctuation of same species have shown differences in abundance or peak from one site to another site which might be the effect of soil type, microbial population, different edaphic parameters and heavy metal content of a particular site. Bellinger (1954) suggested that the habitat preference of soil animal determined by soil microflora with many edaphic factors.

The study of association of earthworms with the soil microorganisms previously recorded by Khambata and Bhatt (1957), Parle (1963a, b), Dash and Cragg (1972), Dash *et al.* (1979), Satchell (1983b), Srinivasulu (1985), Bhattacharya and Chakrabarti (1986), Edwards and Fletcher (1988), Foster (1988), Striganova *et al.* (1989), Tiwari *et al.* (1989), Barois (1992), Daniel and Anderson (1992), Judas (1992), Kristufek *et al.* (1992), Karsten and Drake (1995, 1997), Trigo *et al.* (1999), Wolter and Scheu (1999), Furlong *et al.* (2002), Ihssen *et al.* (2003). Satchell (1974) and Parkinson (1983) reviewed the interactive roles of the litter microflora and fauna in decomposition processes and they reiterated the view that soil invertebrate biomass acted "as a reservoir of plant nutrients" and served as a brake to nutrient leaching from decomposing litter. This implied considerable consumption of microbial tissue (the primary decomposer organisms) by invertebrates.

In this study, the soil microbial community encountered, belonged to ten fungal genera, eleven bacterial genera and two actinomycetes genera (Tables 30 and 33). As stated earlier, the abundance of these forms were varied from one site to other and from season to season (Figs. 88 and 89). The density of most of the dominant taxa in microbial flora generally took remarkable changes throughout the year in which one or two outstanding maximum and minimum population occurred.

Of the ten fungal genera encountered *Penicillium* sp., *Aspergillus* sp. and *Rhizopus* sp. is mentioned in order of dominance (Tab. 30, Fig. 88).

The most prevalent form was *Penicillium* sp. consisting of 60.21% of the total fungi flora obtained during this study and was isolated from all the samples collected for this study. Interestingly the peak population of this genus in each site coincided with that of the peak population of total fungi. The peak population of this genus was found in the month of August in all the studied year (Tables 30 and 31, Figs. 88 and 89).

The second dominant genus was *Aspergillus* sp., built up 18.1% of the total fungal population. Interestingly, this genus holds second dominant position in all the three sampling sites. Its occurrence was most pronounced in Site I (6.97% of total fungi population) and presents in all the samples of Site I and II. But in Site III it exhibited infrequent occurrence. The maximum population of this genus was observed in the month of August in the year 2001 and 2003 and in the month of September in the year 2002 (Tables 30 and 31, Figs. 88 and 89).

The genus *Rhizopus* sp. occupied third dominant position, consisting of 5.49% of the total fungal flora. This form was isolated from all the study sites. The population of this genus was maximum in reserve forest (2.23% of total fungal population). This genus showed maximum population in the month of August and very irregular in occurrence (Tables 30 and 31, Figs. 88 and 89).

The other important fungi isolated were *Fusarium* sp., *Mucor* sp., *Trichoderma* sp., *Cladosporium* sp. and *Cephalosporium* sp. constituted 4.77%, 4.01%, 3.56%, 1.5% and 1.16%, respectively of total fungal population buildup (Tab. 30, Fig. 88).

Among the fungi community encountered in this study, six genera namely *Penicillium* sp., *Aspergillus* sp., *Fusarium* sp., *Rhizopus* sp., *Mucor* sp. and *Trichoderma* sp. were "ubiquitous" indicating their capability to withstand a varying ecological condition in comparison to other four genera. *Cladosporium* sp., *Cephalosporium* sp., *Sclerotium* sp. and *Curvularia* sp. occupied individually very minor position in relation to total fungi community and were termed as "stenoecious" being restricted as localized forms in single sampling site (Tab. 32). Hazra and Choudhuri (1990) also found that the *Penicillium* sp. and *Aspergillus* sp. having capability to tolerate eleven different habitats of West Bengal.

It is evident from the Table 33 and Fig. 91 that in bacteria-actinomycetes community the actinomycetes genus *Streptomyces* sp. outnumbered all the other forms and consisting of 36.48% of total population followed by *Bacillus* sp. (28.94%), *Arthrobacter* sp. (12.49%) and *Micrococcus* I (8.22%).

Maximum isolates of *Streptomyces* sp. obtained from Site II, consisting of 15.30% of total bacteria-actinomycetes population. In Site III this genus consisting of 12.5% of total bacteria-actinomycetes population and in wastes disposal Site it consisting of 8.68% of total bacteria-actinomycetes population. Peak population of this genus occurred in July. However, in the year 2003 the maximum population of this genus were in August (Tables 33 and 34, Figs. 91 and 92). Jensen (1930), Kuster (1968), Kutzner (1968) and Huntjens (1972) identified actinomycetes as a major group of soil microorganisms and mentioned their active participation in turnover of soil organic matter.

In the present study, another genus of actinomycetes namely *Nocardia* sp. was obtained but only from Site II. It consisting of 1.49% of total bacteria-actinomycetes population. The members of the actinomycetes genus *Streptomyces* sp. (constituted 96.06% of actinomycetes population) found to be dominated over the bacterial genera in all the sampling sites except waste disposal area (Tables 33 and 34, Figs. 91 and 92). Prevalence of *Streptomyces* sp. among the soil actinomycetes was also well documented by Davis and Williams (1970); Selin (1971); Alexander (1977). The actinomycetes population was consisting of 37.98% of total bacteria actinomycetes population in this observation. Alexander (1977) observed soil actinomycetes population made up 10-50% of total bacteria-actinomycetes population.

The second dominant form in bacteria-actinomycetes community was the *Bacillus* sp., which consisting of 28.94% of total population. It is interesting to note that only in waste disposal area this genus found to be dominated over the other forms (Tab. 33, Fig. 91). This genus appeared in all samples collected during this study period. Peak population of this genus occurred in August in the year 2001. But in the year 2002 the population maxima were found in the month of September. In the year 2003, peak population was obtained both in the month of January and August (Tab. 34, Fig. 92).

The third major form in bacteria-actinomycetes community was the bacterial genus *Arthrobacter* sp. consisting of 12.49% of total bacteria-actinomycetes population. Maximum number of this genus was obtained from Site II (6.57% of total bacteria-actinomycetes population), followed by Site III (3.41% of total bacteria-actinomycetes population) and Site I (2.51% of total bacteria-actinomycetes population). It was found as a second dominant form in Site II. The peak population of this genus occurred in September in the year 2001 and 2002, but in the month of August in the year 2003 (Tables 33 and 34, Figs. 91 and 92).

In the present study two cocci forms were obtained in the bacterial community, *Micrococcus* I and *Micrococcus* II. *Micrococcus* I occurred in all sites being an important member in microbial community and occupied fourth dominant position in bacteria-actinomycetes community. *Micrococcus* I was abundant in forest site (3.65% of total bacteria-actinomycetes population) whereas *Micrococcus* II was abundant in wastes disposal site (2.03% of total bacteria-actinomycetes population). Population density of *Micrococcus* I was maximum in the month of September in the year 2001 and 2002, whereas for *Micrococcus* II it varies from year to year with irregular occurrence (Tables 33 and 34, Figs. 91 and 92).

In this study *Pseudomonas* sp. and *E. coli* were found to be gram-negative, of which *E. coil* was obtained only from wastes disposal site and consisting of 0.8% of total bacteria-actinomycetes population. The genus *Pseudomonas* sp. was obtained from all the study sites, being maximum in Site II (0.53% of total bacteria-actinomycetes population) followed by wastes disposal site (0.45% of total bacteria-actinomycetes population) (Tables 33 and 34, Figs. 91 and 92). Both this gram-negative strains together constituted 3.68% of total bacteria-actinomycetes population.

The other bacterial genera obtained in this study were *Cytophaga* sp, *Flavobacterium* sp., *Enterobacter* sp., *Promicromonospora* sp. and *Azotobacter* sp. which consisting of 1.68%, 0.24%, 0.53%, 0.9% and 1.33%, respectively of total bacteria-actinomycetes population (Tab. 33).

The Table 35 revealed that, the bacterial genera *Cytophaga* sp., *E. coli*, *Flavobacterium* sp., *Enterobacter* sp. and the actinomycetes *Nocardia* sp. were recorded from only one site and may be called as 'stenoecious' form. On the contrary, the distribution pattern of other five genera namely *Streptomyces* sp., *Bacillus* sp., *Arthrobacter* sp., *Micrococcus* I and *Pseudomonas* sp. suggested their capability to withstand varying ecological conditions and thus they may be termed as 'ubiquitous' (Tab. 35).

Population densities of bacteria-actinomycetes obtained from all the sites showed numerical variations with changes of season. It was minimum when the population of fungi as well as earthworm was also minimum in summer month particularly in the month of May (Tables 4, 9 and 14). In some cases lower population of bacteria-actinomycetes was also obtained during winter season, along with the lower occurrences of earthworm and fungi population (Figs. 16, 44 and 72). Behera and Dash (1981) in Orrisa, Hazra and Choudhuri (1990), Pal *et al.* (1992) in West Bengal found minimum population of fungi only in the month of May. Reduction in the number of microorganism as well as earthworm fauna in summer months and in some winter month may be due to the lower moisture content of the soil. Reduction in population of earthworm in association with decline in fungal and bacteria-actinomycetes population in this study may be one of the reason that microflora especially fungi serves as food for earthworm. Dash and Cragg (1972), Dash *et al.* (1979) opined that fungal hyphae and spores were the major food for earthworm.

The peak population of earthworm and microorganisms were found in the month of August or October *i.e.* in the monsoon and post monsoon season. This significant increase in population may be due to the higher moisture content of soil. Hazra and Choudhuri (1990), Pal *et al.* (1992) opined that significant increase in the moisture content of soil leading to a luxuriant growth of macro and micro flora during monsoon. Present study pointed out that almost similar seasonal fluctuation exists among earthworm fauna and soil microorganisms (Figs. 16, 44 and 72). It might be due to the similar requirements of different soil factors *viz.* temperature, moisture, organic carbon, nitrate, phosphate etc. among the earthworm and microorganisms. It is a well known fact that earthworms prefer various microorganisms as their food (Piearce, 1978; Dash *et al.*, 1979, 1984; Cooke, 1983; Edwards and Fletcher, 1988). So, increase or decrease in the microorganism population might affect the abundance of earthworm population. Lee (1985) opined that there is evidence that earthworms derive much of their nutritional requirements from fungi and microorganisms that are ingested with detritus, so overall rates of cocoon production and seasonal variations in rates may relate more to rates of production of fungal and microbial tissue on decaying detritus than directly to physical parameters of the soil environment. Similar dependence of microflora and earthworms on the nature of available organic matter was reported by Bhat (1974). This situation was also observed by Kale *et al.* (1991) under laboratory conditions.

In this study the population densities of earthworm fauna collected from wastes disposal site was maximum (42.06%), followed by the uncultivated field (37.53%) and forest site (20.40%) (Fig. 87). The bacteria-actinomycetes population was also found in the same sequence among the three sampling sites *i.e.* 36.06%, 32.10% and 31.83%, respectively (Fig. 93). Maximum population of fungi was also obtained from wastes disposal sites (38.89%) and minimum found in uncultivated field (30.04%) (Fig. 90). Highest population of earthworm as well as microflora in wastes disposal site might be due to the higher amount of organic carbon, moisture and available nitrogen content in soil.

The number of isolates of microbial flora obtained from wastes disposal site were under ten bacteria-actinomycetes genera and seven fungal genera; while forest floor harboured seven bacteria-actinomycetes genera and nine fungal genera. On the other hand, in uncultivated field, seven number of each bacteria-actinomycetes and fungal genera were obtained. The increase in number of genera of microflora in waste disposal site and forest floor in comparison to uncultivated field might be due to the presence of higher amount of inorganic and organic nutrients in the form of inorganic and organic wastes in wastes disposal site and litter deposition in the forest soil. Reduction in number of earthworm forms (only three species) in the wastes disposal site was perhaps due to the potential toxic effects of some of the pollutants or heavy metals on earthworm species. However the toxicity of pollutants exerted much adverse effect on the earthworm community compared to fungi or bacteria-actinomycetes communities as it was evident from Table 4, 5 and 6.

As to the role of edaphic factors on the distribution and population pattern of different groups of soil inhabiting microflora and fauna, it might be assumed that the factors analysed in this study exerted both significant and insignificant effects either singly or in a cumulative way, depending on the nature of the site. This could be substantiated if an analysis was made as to the extent of important different factors by taking into consideration the mean value of the soil factors during maximum and minimum population peaks in different sampling sites (Tab. 36). The data in the Table 36 showed that in all sampling sites the population was maximum when the factors like soil relative humidity, organic Carbon, nitrate, phosphate and microflora population also were maximum or significantly high and other conditions were optimum. Reddy and Pasha (1993) concluded that physical soil factors were more important collectively in influencing seasonal variations in populations and distributions than chemical factors.

Soil temperature and moisture appear to be the main driving force for seasonal fluctuation of earthworm population. In the summer months soil temperature was significantly high, thus the minimum population resulted. This may also attributed to both the lesser water content and to the physical instability of the humas layer in the climatic conditions of West Bengal. Evans and Guild (1947) opined that the two soil conditions that affected earthworm activity most were temperature and moisture. In this study as the sampling sites belonged to typical tropical monsoon climate, the variation in soil temperature ranged from 18°C to 37°C in contrast to the subsoil relative humidity content which varied widely ranging from 65% to 100%, resulting in minimum (summer) and maximum (monsoon) populations of earthworm fauna and microflora (Tables 2, 7 and 12, Fig. 94). In the monsoon months when the maximum population occurred; the relative humidity content is recorded to be maximum, also the soil temperature remains higher being more or less near to summer temperature in the climate of Gangetic West Bengal (India), having high precipitation rate and temperature. However it is evident from the Tables 17 and 20 that at Site I earthworm population as well as population of *Lampito mauritii* showed significant positive correlation with soil temperature. In Site II population of *Metaphire posthuma*, *Eutyphoeus orientalis* and *E. incommodus* shows significant positive correlation whereas *Drawida nepalensis* and *D. papillifer papillifer* shows significant negative correlation with soil temperature (Tab. 18). In Site III population of *Metaphire posthuma* and *Eutyphoeus orientalis* shows significant positive correlation with soil temperature (Tab. 19). It may be due to the interspecific variation among the earthworm species for favourable temperature. Bhadauria and Ramakrishnan (1989) found population size was significantly correlated with soil temperature. Lee (1985) opined that tropical earthworm species tend to have higher temperature optima than species from temperate regions. The species of *Drawida* probably favour lower temperature than that of the other studied species. Bhadauria and Ramakrishnan (1989) observed seasonal fluctuations with maximum population size during the wet season for all species except *Amynthas corticis*, which peaked during the winter. The bacteria-actinomycetes population only at Site II shows significant positive correlation with soil temperature. Lower count of bacteria-actinomycetes population during summer may be due to the moisture deficiency in soil for high temperature during that period. Thus the direct influence of temperature on the distribution pattern of earthworm was difficult to evaluate, it might be evaluated in conjunction with the effect of soil humidity. During the study period, the soil humidity content recorded minimum in summer and winter month then earthworm population was also encountered in minimum. It is not easy to define soil temperature for particular earthworms in field conditions, as soil temperature varies with depth and with diurnal and seasonal changes in ambient temperature. High soil temperatures are commonly associated with desiccation and moisture stress and it is not always easy to distinguish the effects of these factors.

In the present study the relative humidity content of soil was recorded to be maximum 100% in the entire three studied site and minimum 56% in surface soil and 65% in sub soil in Site II (Tables 2, 7 and 12). So a wide range of variation was observed in different sites in different season (Fig. 94). There was significant positive correlation between soil humidity and earthworm population in all the studied fields (Tab. 20). Similar observation was also made by Reddy and Alfred (1978), Ismail and Murthy (1985), Senapati and Sahu (1993). Among earthworm fauna *Lampito mauritii*, *Metaphire posthuma*, *Eutyphoeus orientalis*, *E. incommodus* and *E. nicholsoni* shows significant positive correlation with soil humidity (Tabs. 17-19). Julka and Mukherjee (1984) observed seasonal activity of earthworms in hill forest soil and found a significant positive correlation between the soil moisture and changes in the population size of predominant species *Octolasion tyrtaeum*. Tiwari *et al.* (1992) also found a significant correlation between earthworm populations and temperature and moisture in a pineapple field. Jairajpuri (1993) opined that the soil temperature and moisture are two important factors that influence seasonality and distribution of earthworm.

Highly significant positive correlation with earthworm population and its monsoon and post monsoon population peak has been found in all the study sites. Increase in biomass correlates with increase in moisture content of the soil also supported by the observation of Kaleemurrahman and Ismail (1981). El-Duweini and Ghabbour (1965) investigated the survival of *Aporrectodea turgida* in relation to soil moisture content in Egypt, had reported that an increase in moisture content of from 15 to 34% was associated with an increase in numbers of *Aporrectodea turgida*, but above 34% extra moisture had no effect. Wood (1974) showed that there was a strong positive correlation between earthworm biomass and increased soil moisture content for topsoil-inhabiting earthworm species. Bhadauria and Ramakrishnan (1989) found population size was significantly correlated with soil moisture. Optimum soil moisture contents for earthworm activity are not the same for all species and it is apparent that even within species there is considerable scope for adaptation (Lee, 1985). Julka and Paliwal (1989a) studied the seasonal fluctuations in the population of earthworms in a plum orchard and found a significant positive correlation between the combined influence of soil temperature and soil moisture with that of the seasonality of the earthworms. Jairajpuri (1993) opined that in sub-tropical climate India, earthworms are active and abundant mainly during summer rains. Lee (1985) also opined that high mortality is related more closely to seasonal variations in soil moisture than in soil temperature. Temperature and moisture are usually inversely related and high surface temperatures and dry soils are much more limiting to earthworms than low temperatures and waterlogged soils (Nordström and Rundgren, 1974). Microbial population also shows significant positive correlation with soil humidity in all the studied sites (Tab. 20). Similar was the observation of Laudelout *et al.* (1978). In case of fungi this study is also supported by the observations of Hazra and Bhattacharyya (2003). From the information available it might be assumed that the moisture content of soil exerted direct or indirect influence on the faunal and microfloral population by i) maintaining the soil reaction, ii) controlling humification and nutrification, iii) stimulating the growth of macro- and microflora.

The content of organic Carbon varied between 0.63% and 4.23% (Fig. 94) in the present study and exhibited significant positive correlations with the earthworm, fungi and bacteria-actinomycetes population in forest floor (Tab. 20). Same was the observation by Senapati and Sahu (1993) for earthworm population. Present study pointed out that except *Perionyx excavatus* and *Metaphire posthuma* in Site II other species *viz. Lampito mauritii, Metaphire posthuma, Drawida nepalensis, D. papillifer papillifer, Polypheretima elongata, Perionyx simlaensis, Eutyphoeus nicholsoni, Metaphire houlleti, Octochaetona beatrix* shows significant positive correlations with organic Carbon (Tabs. 17-19). Increases in the organic Carbon content of fourteen Egyptian soils were associated with increased numbers and biomass of earthworm (El-Duweini and Ghabbour, 1965; Ghabbour and Shakir, 1982). Ismail and Murthy (1985) opined that organic matter of soils is generally positively correlated to earthworm distribution. Hendrix *et al.* (1992) showed a strong positive correlation between earthworm population density and soil organic matter content. Bhadauria and Ramakrishnan (1989) found population size was significantly correlated with soil organic matter. Bhadauria *et al.* (1997) observed that the addition of organic manure encouraged increase in the earthworm populations. Choudhuri and Mitra (1983) observed that the earthworm population as well as the diversity of species was maximum in August being positively correlated with the corresponding higher values of soil moisture, temperature and organic Carbon. The high temperature and low moisture content of soil seemed to influence the amount of organic Carbon as it was evident from the present study that during summer, soil contained less amount of organic carbon which might be due to low moisture level and ready oxidation occurring in organic matter.

Another important factor that affecting the population fluctuation of soil biota is soil pH. It was measured minimum 5.66 at Site I and maximum 7.9 at Reserve forest (Tables 2 and 12). The graphical presentation of seasonal changes of pH is exhibiting very little fluctuation (Fig. 94). Hazra and Choudhuri (1983) opined that more or less neutral pH was favourable to soil organisms. Present study shows that soil pH has significant positive correlations with the earthworm population in waste disposal site (Tab. 20) and with fungi population in uncultivated field (Tab. 20). Reddy and Alfred (1978), Senapati *et al.* (1979) also reported a positive correlation of earthworm biomass or population size to soil pH. Reddy and Pasha (1993) also reported a significant positive correlation between pH and the seasonal abundance of juvenile and young adult of *Octochaetona phillotti* in semi-arid tropical grassland in India, but the populations of adult earthworms was affected more by rainfall than by pH. Hazra and Chowdhury (1990) have reported that soil pH may exert indirect influence on the growth and activities of soil micro and macro flora and also the vegetation and other physiochemical properties of soil. Most species of earthworms prefer soils with a pH of about 7.0 (Arrhenius, 1921; Moore, 1922; Bodenheimer, 1935; Petrov, 1946). The effects of soil pH on lumbricid earthworms were reviewed by Edwards and Lofty (1977); the preferences and tolerances of most species appear to fall in the ubiquitous range (Satchell, 1955) *i.e.* 3.7-7.0. There is little information on the pH preferences and tolerances of nonlumbricid earthworms. Lee (1959) found no megascolecids in New Zealand soils with pH < 4.0 and no obvious relationship had been observed between species distribution and pH. Bano and Kale (1991) reported that the moisture and pH play an important role in distribution of earthworm. Baath (1989) commented that, different process in soil are pH dependent; therefore, it will be difficult to differentiate or to assess the effects due to pH changes or other parameters like toxicity of heavy metals under field condition. Soil pH is related to other soil factors that have an important influence on earthworm populations; it is often difficult to establish a direct cause and effect relationship between soil pH and the size of earthworm populations (Edwards and Bohlen, 1996).

The categories of soils with respect to conductivity *i.e.* total soluble salts in the soils in the present studied sites showing more or less with in normal range (Tabs. 2, 7 and 12, Fig. 94). Maximum being occur in both wastes disposal and uncultivated site (1.5 dSm^{-1}) and minimum both in Reserve forest and uncultivated field (0.1 dSm^{-1}). From Table 20 it has been found that in every case it showed negative correlations with earthworm, fungi and bacterial population, but significant negative correlation found only in uncultivated field. Salinity exerts its influence on earthworm fauna and microflora by changing the osmotic pressure of surrounding water. Kale and

Krishnamoorthy (1978) observed that the moisture content, salinity and organic matter concentration were the principal factors controlling the distribution and bionomics of the earthworm population.

Available Nitrogen content of the soil measured maximum 520 kg ha^{-1} at waste disposal site and minimum 170 kg ha^{-1} in forest floor (Tables 2 and 12). A strong positive correlation found between soil available nitrate and earthworm population, as well as with fungi population in Site II (Tables 18, 20). Similar significant positive correlation also observed by Christensen (1991). Significant positive correlation also observed between soil available nitrate and fungi population, as well as with bacteria-actinomycetes population in forest site (Site III) (Tables 19 and 20). Availability of adequate Nitrogen appears to be one of the most important factors limiting earthworm populations and their distribution, especially in tropical regions, where the Nitrogen content of soils is low compared with that of soils of temperate regions (Lee, 1983). The organic Carbon, available nitrate is a measure of the quality of soil organic matter as an energy source. It is also an important determinant of humus types and is related to soil moisture, pH and too many other soil properties. Evans and Guild (1948) showed that earthworms fed on Nitrogen rich diets grew faster and produced more cocoons than those with little Nitrogen available. Wittich (1953) observed that the litter most readily consumed by earthworms was generally Nitrogen rich. The nitrate as essential macronutrients of plant probably exerts its influence on earthworm population through vegetation. The availability of adequate organic Carbon and Nitrogen in assimilable forms is essential for the survival and growth of all animals. Absolute deficiency of one or both elements sometimes limits earthworm populations (Lee, 1985). Satchell (1967) regarded Nitrogen content of food materials as the critical factor limiting earthworm populations in heathlands and grasslands in England and Lee (1983) concluded that the same restriction must also apply to tropical earthworm populations. In the monsoon months increased content of moisture stimulated decomposition, ammonification and nitrification through activities of some bacteria and resulted to a higher nitrate level. Therefore, it might be assumed that the content of nitrate brought about appreciable changes in both macro- and micro- climates and thus led to population fluctuations.

In the present investigation the available Phosphate content of the soil measured maximum 314.2 $kgha^{-1}$ in wastes disposal site and minimum 94 $kgha^{-1}$ at uncultivated field (Tables 2 and 7). Strong positive correlation found between soil available Phosphate and earthworm population in waste disposal site (Tab. 20). Nuutinen *et al.* (1998) opined that earthworm populations have been associated with soil extractable Phosphate. Significant positive correlation also exists between available Phosphate and fungi flora at Site II (Tab. 20). But at forest floor bacterial population shows significant negative correlation with available Phosphate (Tab. 20). Thus the present study pointed out that the relation between soil Phosphate and microorganism are not consistent. It may be assumed that Phosphate as a single factor did not exert any significant influence on the population but in combination with other factors might contribute to the population of soil biota.

Available Potassium content of the soil measured maximum 785 kg ha^{-1} at waste disposal site and minimum 180 kg ha^{-1} in uncultivated field (Tables 2 and 7). Strong positive correlation found between soil available Potassium and earthworm population, as well as with fungi and bacteria-actinomycetes populations in waste disposal site (Tab. 20). Strong positive correlation also found between soil available Potassium and earthworm population, as well as with bacteria-actinomycetes population in forest site (Tab. 20). In contrast to this, significant negative correlation exists between soil available Potassium and microbial population in uncultivated site (Tab. 20). So relation between soil available Potassium and microorganisms was not consistent, but with earthworm population it is very significant. Probably Potassium along with Nitrogen and phosphate exerts its influence through plant debris, which serves as food for earthworm.

In the heterogeneous atmosphere of soil, the heavy metals, as nondegradable substances accumulated in the upper layer of soil mainly in the organic part of the soil profile where the biological activities are maximum and thus the decomposer organisms inhabiting the litter layer suffer more from metal exposure. In natural polluted soil, never a single metal is found to be responsible for toxicity of soil habitat; it is mainly by the cumulative effect of all the possible metals.

In this investigation, a simple comparative approach was made to demonstrate the impact of heavy metals like Cd, Zn, Pb and Cu on the earthworm population as well as on soil bacteria-actinomycetes and fungi population by correlation study. But it is very difficult to evaluate the impact of single metal on soil earthworm fauna or microbial flora.

The concentration levels of heavy metals in the soil found in the present study showed wide range of variation from 0.2 ppm to 6.25 ppm Cadmium, 40 ppm to 750 ppm Zinc, 15 ppm to 410 ppm Lead and 14 to 300 ppm Copper (Tables 2, 7 and 12). Strong negative correlation exists between all studied heavy metals and earthworm as well as microbial population in Site II and III (Tab. 20). In Site I, Zn and Pb shows significant negative correlation with earthworm population (Tab. 20). It is interesting to note that earthworm species *Perionyx excavatus* exhibited significant positive correlations with all the studied heavy metals in Site II and Site III (Tables 18 and 19). So this species may be tolerant to all this studied metals when other factors remain in optimum condition. In all the studied sites, populations were found to be maximum when the concentration levels of these heavy metals were significantly low and minimum in summer, when the levels of metals were high. Due to the low rainfall for more than three months in summer, the deposited solid wastes remain over the soil surface and during monsoon it perhaps percolates through the soil pores.

It is interesting to note that the highest concentration levels of all the metals were recorded in the waste disposal site that supported the maximum population densities of soil microflora and earthworm fauna particularly the species *Lampito mauritii*. The main source of metals in the soil may be the garbage material dumped by Kolkata Municipal Corporation. The wastes mainly include household's refuge, industrial discharges and residues of different vegetables that might have contributed a lot to the organic matter in this field. Among the all studied sites the wastes disposal site also recorded highest organic Carbon content in the soil, which might be an important factor in reducing the toxicity of metals (Fig. 94). Similar was the observation of Baath (1989). Since the soil environment is very heterogeneous, metal concentration might vary greatly between microhabitats that are different with respect to the soil texture and organic matter. The bioavailability of these metals might be influenced by the other abiotic factors *viz.* organic Carbon, pH, moisture and temperature. It is difficult to evaluate the influence of any parameter in a field study, as in natural condition these factors interact together and exert cumulative effect.

On the other hand, the waste disposal site witnessed a decline in earthworm species diversity as compared to other two sites. Bengtsson *et al.* (1988) concluded that, the common effect of metal contamination in all the invertebrates is a decrease in species diversity. According to them, the total abundance is not clearly affected, as decrease in some species is compensated for by and increase number of individual of more tolerant species. Present study pointed out that low diversity in earthworm community in polluted soil is associated with the predominance of one species *Lampito mauritii* (94.3%), which may be due to the development of increased tolerance to the toxicity of the studied heavy metals by this species. In present study some fungal genera namely, *Penicillium* sp., *Aspergillus* sp., *Fusarium* sp., *Trichoderma* sp. and *Cephalosporium* sp. were found to be more abundant in wastes disposal site in comparison to other two sites. Pugh *et al.* (1975) found a metal sensitive species of *Trichoderma*. Jensen (1977) while examining the effect of Lead noticed the occurrence of the dominant species of *Fusarium*. However, no definite conclusion could be drawn as to whether the microflora and earthworm fauna collected from the wastes disposal sites, which contained a rather high level of various heavy metals were tolerant populations. Further studies should be made on the toxicity of heavy metals on the microflora and earthworm fauna collected from this highly polluted area.

The composition of bacterial population encountered from waste disposal site was dominated by gram positive taxa *Bacillus* sp. (15.63% of total bacteria-actinomycetes population). The actinomycetes represented by *Streptomyces* sp. obtained minimum from this site (8.68% of total bacteria-actinomycetes population), while Kandaswamy *et al.* (1981) found no growth of actinomycetes in the effluent added soil from chemical industries.

Besides the geographical position and composition of the habitats, the earthworm communities were probably regulated by a number of factors. Soil fertility, soil profile, humus type, water content and microfloral conditions might have influenced their distribution and life conditions in environmentally poorest and richest soils. It is revealed from the present study that the heavy metals *viz.* Cd, Zn, Pb and Cu were negatively correlated with soil microbial flora and earthworm fauna. On the basis of the results obtained here, it might be inferred that the absence or lower population of earthworm communities may be used as an indicator of damage soil environment. It is not possible to conclude definitely with the variation of single earthworm species. However, the earthworm community as a whole may be consider as an indicator for the damage soil ecosystem.

It might be inferred from the present study that the biotic and abiotic factors evaluated here in conjunction with the other factors not considered in this study collectively contributed to the population fluctuation and the distribution pattern of earthworm fauna and microflora in the different habitats of tropical climate of Eastern India.

Lastly, it would be worth mentioning that any attempt to unravel the interactions between edaphic factors and earthworm / microflora population would be abortive unless the behaviour of individual earthworm species in relation to each factor and pollutant were separately studied under controlled laboratory condition.

SUMMARY

1. Present studies contained results of taxonomy, ecology and microbiological study involving the impact of different soil factors and some heavy metal pollutants on earthworm and microbial population and association of earthworms with microbial populations from three different *viz.* polluted, uncultivated and forest habitats of West Bengal.

2. A total of 1200 soil samples were drawn from various plots at monthly intervals over a period of twenty five months (June 2001 to August 2003). Among the plots sampled, four had polluted soil environment, four were from an uncultivated field and remaining four were from the forest floor that was affected by flood in the year 2001.

3. Soil factors like temperature, relative humidity, pH, organic Carbon, electrical conductivity, available Nitrogen, available Phosphate, available Potassium and heavy metals such as Cadmium, Zinc, Lead and Copper were taken into consideration. Fungi and bacteria-actinomycetes population and their interactions with these parameters and earthworm fauna were also studied. All these were found to vary sampling sitewise and seasonally.

4. Population density of total earthworm, fungi and bacteria-actinomycetes in order of abundance were 42.06%, 38.89% and 36.06%, respectively at waste disposal site; 37.53%, 30.04% and 32.10%, respectively at the uncultivated field; 20.40%, 31.06% and 31.83%, respectively at forest floor.

5. The earthworm fauna encountered, belonged to fourteen species including three new records from West Bengal *viz. Perionyx simlaensis, Octochaetona surensis, Drawida papillifer papillifer* under 8 genera of the families Megascolicidae, Octochaetidae and Moniligastridae. Moreover, the number of genera occurring in the different sampling sites also varied, maximum species diversity was obtained both from the reserve forest floor (ten species under seven genera) and uncultivated field (ten species under six genera) and minimum diversity of species was recorded in the wastes disposal site. Species composition of earthworm of three different habitats differed considerably, only seven species of earthworms out of total fourteen species were found to occur in all the habitats namely *Lampito mauritii, Metaphire posthuma, Perionyx excavatus, Eutyphoeus orientalis, Eutyphoeus incommodus, Drawida nepalensis, Metaphire houlleti,* while the species *viz. Eutyphoeus nicholsoni, Amynthas corticis, Octochaetona beatrix* found to occur only in Reserve forest floor, *Perionyx simlaensis, Polypheretima elongata, Octochaetona surensis, Drawida papillifer papillifer* were restricted to only uncultivated field.

6. Fungal population studied belonged to ten genera and the bacteria-actinomycetes community comprised of eleven bacterial genera and two actinomycetes genera. Six genera of fungi namely *Penicillium* sp., *Aspergillus* sp., *Fusarium* sp., *Rhizopus* sp., *Mucor* sp. and *Trichoderma* sp.; four genera of bacteria namely *Bacillus* sp., *Arthrobacter* sp., *Micrococcus* and *Pseudomonas* sp. and the actinomycetes strain *Streptomyces* sp. were found in all the three habitats studied. On the other hand four genera of fungi *Cladosporium* sp., *Cephalosporium* sp., *Sclerotium* sp. and *Curvularia* sp.; four genera of bacteria *Cytophaga* sp., *E. coli, Flavobacterium* sp., *Enterobacter* sp. and one genus of actinomycetes *Nocardia* sp. were found to be confined to a particular site.

7. Numerically the genus *L. mauritii* occupied topmost position among all the earthworms and was widely distributed. *Eutyphoeus* and *Drawida* respectively occupied second and third position and the other genera like *Metaphire, Perionyx, Polypheretima* and *Octochaetona* mentioned in order of dominance. Populations of most of the other genera were numerically low and irregular in distribution pattern.

8. In order of dominance the *Penicillium* sp. and *Streptomyces* sp. occupied topmost position among the fungal and bacteria-actinomycetes communities respectively.

9. Population density of both earthworm fauna and microflora varied considerably from month to month, season to season in different habitats. The population peak was also varied from one site to other, usually minimum in summer and dry winter month. The peak population of earthworm and microorganisms found to be coincided in all sites in respective months, like during monsoon or post monsoon period.

10. The fluctuation of populations of both earthworm and microorganisms showed a regular trend in some major species, but majority of earthworms and microbial genera exhibited irregular trend.

11. When the correlation was examined in respect to the population of earthworm fauna and microbial flora, in all cases it showed a significant positive relationship.

12. It is evident from analysis of variance that site wise fluctuation of earthworm population as well as different species namely, *Lampito mauritii*, *Metaphire posthuma*, *Perionyx excavatus*, *Eutyphoeus orientalis*, *Eutyphoeus incommodus*, *Drawida nepalensis* and *Metaphire houlleti* were significant. In the fungal community site wise significant fluctuation shown by fungal population and different genera of fungi *viz. Penicillium* sp., *Aspergillus* sp., *Fusarium* sp., *Trichoderma* sp. and *Cladosporium* sp. It is evident that sitewise fluctuation of bacteria-actinomyetes population as well as individual genera *viz. Streptomyces* sp., *Micrococcus* I, *Micrococcus* II, *Arthrobacter* sp., *Pseudomonas* sp., *Promicromonospora* sp., *Azotobacter* sp. was significant. It is also evident from analysis of variance that except *Eutyphoeus nicholsoni*, *Drawida nepalensis*, *Amynthas corticis* and *Octochaetona beatrix* all other earthworm species as well as earthworm population shows significant seasonal fluctuation. In the fungal community significant seasonal fluctuation were shown by fungi population and different genera of fungi except *Cephalosporium* sp. and *Sclerotium* sp. Except *Arthrobacter* sp., *E. coli*, *Azotobacter* sp. and *Nocardia* sp. all other bacteria-actinomycetes genera as well as bacteria-actinomycetes population shows significant seasonal fluctuation.

13. Of the soil factors subsoil relative humidity showed strong positive correlations with earthworm population as well as with microbial populations in all the studied sites. Soil temperature showed significant positive correlation with earthworm population only in waste disposal site and with bacteria-actinomycetes population in uncultivated site. The soil pH shows strong positive correlation with earthworm population in waste disposal site, whereas, it exhibit significant positive correlation with fungi population in uncultivated site only. In all cases electrical conductivity of soil shows negative correlation with earthworm as well as microbial population, but it was significant only in uncultivated field. Significant positive

correlation found between organic Carbon and earthworm as well as with microorganisms in only forest floor. Available Nitrogen content of soil shows significant positive correlation with earthworm and fungi population in uncultivated field, not only that it also shows significant positive correlation with fungi and bacteria-actinomycetes population in forest site.

14. The heavy metal pollutants like Cadmium, Zinc, Lead and Copper showed significant negative correlation with earthworm and microorganisms in all the sites. Strong negative correlation found between Cadmium and earthworm as well as with microorganisms in uncultivated field and forest floor. Zinc shows significant negative correlation with earthworm population in all the sites but with microorganisms it shows significant negative correlation in uncultivated field and forest site only. Lead and Copper showed strong negative correlation with both earthworm and microbial populations in uncultivated and forest sites and in waste disposal site Lead shows significant negative correlation with only earthworm population.

15. As the population of earthworm, fungi and bacteria-actinomycetes are interrelated or interdependent and depend upon the soil factors. As there is no a *priori* theory about the governing variables, the Stepwise Linear Regression analysis revealed that, these are subjected to change, *i.e.* the type and number of variables found to be important for the population density of earthworm forms varied for different species in a given site as well as for a same species in different sites.

16. From the present investigation it might be inferred that the effect of dumping of municipal wastes on soil surface which caused the polluted soil environment reduced the total soil fauna both quantitatively and qualitatively specially the earthworm community. Thus, the reduction of these active biological agents the process of soil formation would be very slow associated with the drastic ultimate effects on the soil health in general.

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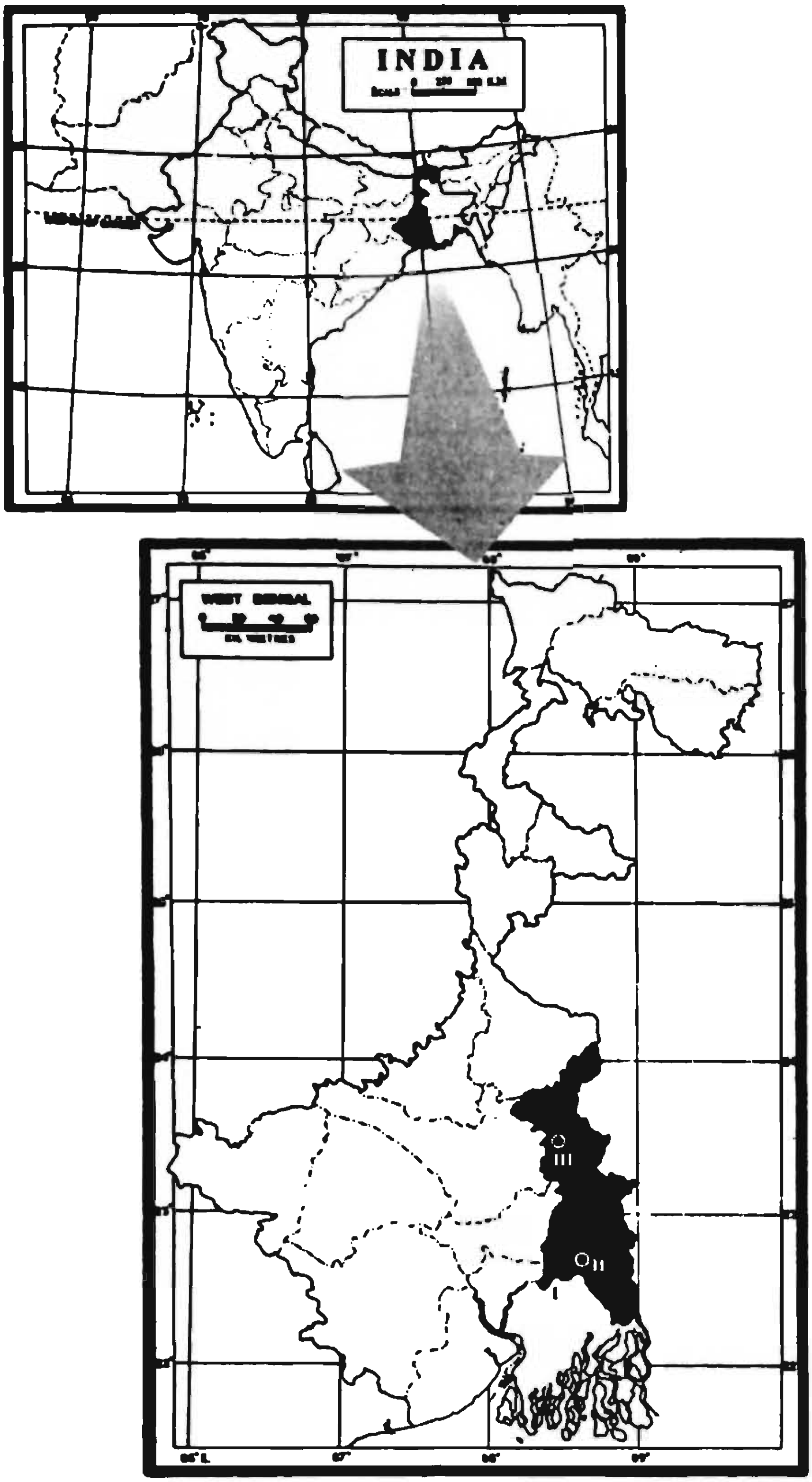


I – Site I (DP)
II – Site II (MD)
III – Site III (BRF)

Map 1 : Location of sampling sites
I = Site I, Dhapa (DP), Municipal wastes disposal site, Kolkata; II = Site II, Madhyamgram (MD), uncultivated field, North 24 Pgs.; III = Site III, Bethuadahari Reserve Forest (BRF), Nadia

Table 2 : Showing total and individual species population of earthworm (nos. / m²), values of edaphic factors and heavy metals at Site - I (DP).

Month	Total earthworm (nos. / m²)	E1	E2	E3	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
June '01	71	70	1	0	29	26	70	86	7.1	0.25	3.66	370	180	504	4	550	280	201
July '01	108	106	2	0	34	29	80	92	7.2	0.36	3.54	403	190	596	3	580	270	220
Aug. '01	133	127	6	0	31	29	83	96	7.3	0.63	3.86	386	150	698	3	600	290	220
Sept. '01	119	118	1	0	30	27	80	95	7 1	0.56	3.33	398	286	644	3	600	301	170
Oct. '01	81	79	2	0	28	26	80	91	7.08	0.76	3.46	520	205	674	2.75	630	345	265
Nov. '01	82	79	3	0	28	25	65	86	7.15	0.36	2.69	376	201	702	2.5	650	320	250
Dec. '01	81	80	1	0	22	18	70	82	7.2	0.33	3.02	402	125	572	2.5	650	360	270
Jan. '02	69	68	1	0	20	17	65	80	6.86	0.84	3.29	356	185	494	2.75	670	390	300
April '02	78	77	1	0	35	30	60	78	7.22	0.3	2.96	350	265	348	5	650	320	250
May '02	68	66	2	0	34	30	66	80	7.16	0.59	3.23	385	288	452	6	650	320	210
June '02	62	62	0	0	28	27	85	99	7.15	0.22	2.94	480	227.4	536	5	610	260	230
July '02	119	113	6	0	33	30	85	94	7.24	0.31	3.86	462	192	548	4	610	260	210

Table 2 : (Contd.)

Month	Total earthworm (nos. / m^2)	E1	E2	E3	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
Aug. '02	143	139	4	0	32	29	87	100	7.3	0.67	3.73	475	270	646	4	580	300	190
Sept. '02	134	134	0	0	29	27	80	92	7.15	0.35	3.5	420	314.2	536	6.25	650	330	250
Oct. '02	76	76	0	0	27	26	75	84	6.9	0.9	2.33	455	291	736	3	660	316	204
Nov. '02	92	91	1	0	30	28	70	86	7.2	0.42	2.55	386	272	710	3	630	380	190
Dec. '02	52	44	8	0	21	18	80	88	7.3	0.29	2.86	379	247.7	690	2.5	690	350	300
Jan. '03	2	1	1	0	24	22	65	80	6.94	0.91	3.46	395	102	644	3	650	410	220
Feb. '03	8	8	0	0	23	20	75	82	6.5	1.5	3.39	456	92	360	6.25	680	380	200
Mar. '03	48	48	0	0	28	24	75	78	6.93	0.73	3.38	470	227	380	5.5	750	400	166
April '03	88	69	0	19	32	28	72	80	7.38	0.19	2.21	504	254	440	4	630	340	220
May '03	67	50	1	16	33	29	73	78	7.2	0.62	3.23	386	214	536	5	650	322	195
June '03	65	42	15	8	31	29	72	80	7.16	0.18	4.23	504	250	500	5	570	285	210
July '03	101	96	5	0	30	28	80	95	7.16	0.23	3.68	437	288	636	3	580	250	200
Aug. '03	135	124	11	0	30	27	86	98	6.9	0.7	4.1	510	300	785	3	600	270	170

Explanations : *E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus*

Table 3 : Showing abundance of total and individual earthworm species obtained per month from Site I: DP (expressed in %)

Month	Total earthworm	E1	E2	E3
June '01	3.41	3.36	0.04	–
July '01	5.18	5.09	0.09	–
Aug. '01	6.38	6.09	0.28	–
Sept. '01	5.71	5.66	0.04	–
Oct. '01	3.89	3.79	0.09	–
Nov. '01	3.93	3.79	0.14	–
Dec. '01	3.89	3.84	0.04	–
Jan. '02	3.31	3.26	0.04	–
April '02	3.74	3.69	0.04	–
May '02	3.26	3.17	0.09	–
June '02	2.97	2.97	–	–
July '02	5.71	5.42	0.28	–
Aug. '02	6.86	6.67	0.19	–
Sept. '02	6.43	6.43	–	–
Oct. '02	3.65	3.65	–	–
Nov. '02	4.41	4.37	0.04	–
Dec. '02	2.49	2.11	0.38	–
Jan. '03	0.09	0.04	0.04	–
Feb. '03	0.38	0.3	–	–
Mar. '03	2.30	2.3	–	–
April '03	4.22	3.31	–	0.91
May '03	3.21	2.4	0.04	0.76
June '03	3.12	2.01	0.72	0.38
July '03	4.85	4.61	0.24	–
Aug. '03	6.48	5.95	0.52	–
TOTAL		94.3	3.34	2.05

Explanations : *E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus*

Table 4 : Showing total population of Earthworm, Fungi, Bacteria-Actinomycetes, values of edaphic factors and heavy metals at Site - I (DP).

Month	Earthworm (nos. / m^2)	Fungi (no. of CFU X 10^3/gm.)	Bacteria-actinomycetes (no. of CFU X 10^5/gm.)	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
June '01	71	26	36	29	26	70	86	7.1	0.25	3.66	370	180	504	4	550	280	201
July '01	108	38	68	34	29	80	92	7.2	0.36	3.54	403	190	596	3	580	270	220
Aug. '01	133	62	83	31	29	83	96	7.3	0.63	3.86	386	150	698	3	600	290	220
Sept. '01	119	50	49	30	27	80	95	7.1	0.56	3.33	398	286	644	3	600	301	170
Oct. '01	81	33	52	28	26	80	91	7.08	0.76	3.46	520	205	674	2.75	630	345	265
Nov. '01	82	37	76	28	25	65	86	7.15	0.36	2.69	376	201	702	2.5	650	320	250
Dec. '01	81	32	35	22	18	70	82	7.2	0.33	3.02	402	125	572	2.5	650	360	270
Jan. '02	69	33	34	20	17	65	80	6.86	0.84	3.29	356	185	494	2.75	670	390	300
April '02	78	32	21	35	30	60	78	7.22	0.3	2.96	350	265	348	5	650	320	250
May '02	68	23	20	34	30	66	80	7.16	0.59	3.23	385	288	452	6	650	320	210
June '02	62	33	53	28	27	85	99	7.15	0.22	2.94	480	227.4	536	5	610	260	230
July '02	119	32	60	33	30	85	94	7.24	0.31	3.86	462	192	548	4	610	260	210

Table 4 : (Contd.)

Month	Earthworm (nos. / m^2)	Fungi (no. of CFU X 10^3/gm.)	Bacteria-actinomycetes (no. of CFU X 10^5/gm.)	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})	O C (%)	Available N_2 (Kgha^{-1})	Available P_2O_5 (Kgha^{-1})	Available K_2O (Kgha^{-1})	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
Aug. '02	143	48	61	32	29	87	100	7.3	0.67	3.73	475	270	646	4	580	300	190
Sept. '02	134	42	97	29	27	80	92	7.15	0.35	3.5	420	314.2	536	6.25	650	330	250
Oct. '02	76	41	58	27	26	75	84	6.9	0.9	2.33	455	291	736	3	660	316	204
Nov. '02	92	35	59	30	28	70	86	7.2	0.42	2.55	386	272	710	3	630	380	190
Dec. '02	52	33	39	21	18	80	88	7.3	0.29	2.86	379	247.7	690	2.5	690	350	300
Jan. '03	2	18	74	24	22	65	80	6.94	0.91	3.46	395	102	644	3	650	410	220
Feb. '03	8	25	22	23	20	75	82	6.5	1.5	3.39	456	92	360	6.25	680	380	200
Mar. '03	48	30	34	28	24	75	78	6.93	0.73	3.38	470	227	380	5.5	750	400	166
April '03	88	38	49	32	28	72	80	7.38	0.19	2.21	504	254	440	4	630	340	220
May '03	67	18	31	33	29	73	78	7.2	0.62	3.23	386	214	536	5	650	322	195
June '03	65	29	59	31	29	72	80	7.16	0.18	4.23	504	250	500	5	570	285	210
July '03	101	34	68	30	28	80	95	7.16	0.23	3.68	437	288	636	3	580	250	200
Aug. '03	135	48	112	30	27	86	98	6.9	0.7	4.1	510	300	785	3	600	270	170

Table 5 : Showing abundance of total and individual fungal genera obtained per month from Site I : DP (expressed in %).

Genera	June '01	July '01	Aug. '01	Sept. '01	Oct. '01	Nov. '01	Dec. '01	Jan. '02	April '02	May '02	June '02	July '02	Aug. '02
Penicillium	1.49	1.49	3.79	4.36	1.95	2.64	2.18	2.64	2.64	1.26	2.64	1.60	3.21
Aspergillus	0.68	1.72	1.03	0.68	1.03	1.37	0.80	0.80	0.11	0.57	0.57	1.26	0.80
Fusarium	0	0	0.45	0.45	0.57	0	0.11	0.34	0	0.11	0	0.34	0.57
Trichoderma	0.45	0.22	1.26	0.22	0	0	0	0	0.22	0	0	0.11	0.45
Rhizopus	0.11	0.68	0.22	0	0	0	0.11	0	0.57	0	0.22	0.34	0
Cephalosporium	0	0	0	0	0	0.22	0.45	0	0	0.68	0.11	0	0.34
Mucor	0.22	0.22	0.34	0	0.22	0	0	0	0.11	0	0.22	0	0.11
Total	2.98	4.36	7.12	5.74	3.79	4.25	3.67	3.79	3.67	2.64	3.79	3.67	5.51

Genera	Sept. '02	Oct. '02	Nov. '02	Dec. '02	Jan. '03	Feb. '03	Mar. '03	April '03	May '03	June '03	July '03	Aug. '03	Total
Penicillium	3.10	2.52	2.87	2.98	1.49	1.26	1.72	3.79	1.83	2.52	2.06	3.79	61.95
Aspergillus	0.57	0.45	0.91	0.45	0.45	0.22	0.45	0.34	0.11	0.80	0.80	0.80	17.93
Fusarium	0.57	0.22	0	0.34	0.11	0.80	0.22	0.11	0.11	0	0.34	0.22	6.09
Trichoderma	0	0.45	0.22	0	0	0.57	0.34	0.11	0	0	0.11	0.45	5.28
Rhizopus	0.22	0	0	0	0	0	0.34	0	0	0	0.34	0	3.21
Cephalosporium	0	0.80	0	0	0	0	0.22	0	0	0	0	0.11	2.98
Mucor	0.34	0.22	0	0	0	0	0.11	0	0	0	0.22	0.11	2.52
Total	4.82	4.71	4.02	3.79	2.06	2.87	3.44	4.36	2.06	3.33	3.90	5.51	

Table 6 : Showing abundance of total and individual bacteria-actinomycetes genera obtained per month from Site I : DP (expressed in %).

Genera	June '01	July '01	Aug. '01	Sept. '01	Oct. '01	Nov. '01	Dec. '01	Jan. '02	April '02	May '02	June '02	July '02	Aug. '02
Bacillus	1.55	2.44	2.74	2.66	2.14	0.96	1.62	0.81	0.37	0.81	2.14	1.70	2.29
Streptomyces	0.37	1.33	0.96	0.59	0.88	1.25	0.37	0.22	0.88	0.44	1.11	1.92	0.66
Micrococcus I	0.37	0.51	0.81	0	0	0.66	0.22	0.22	0.14	0.22	0.22	0	0.37
Micrococcus II	0	0	0.51	0.22	0.29	0.29	0	0.22	0	0	0.29	0	0.29
Arthrobacter	0.14	0.59	0.22	0	0.07	0.51	0	0.22	0.14	0	0.14	0.22	0.66
Pseudomonas	0.22	0	0	0.14	0	0	0	0.07	0	0	0	0.22	0
Promicromonospora	0	0	0	0	0.44	0	0	0.14	0	0	0	0	0
Cytophaga	0	0.14	0.59	0	0	0.96	0	0	0	0	0	0.14	0.22
E. coli	0	0	0.22	0	0	0.51	0.22	0.14	0	0	0	0	0
Flavobacterium	0	0	0	0	0	0.22	0.14	0	0	0	0	0	0
Enterobacter	0	0	0.07	0	0	0.22	0	0.44	0	0	0	0.22	0
Total	2.66	5.03	6.14	3.62	3.85	5.62	2.59	2.51	1.55	1.48	3.92	4.44	4.51

Genera	Sept. '02	Oct. '02	Nov. '02	Dec. '02	Jan. '03	Feb. '03	Mar. '03	April '03	May '03	June '03	July '03	Aug. '03	Total
Bacillus	3.03	2.44	0.66	2	2.44	0.37	0.96	1.03	0.66	2.59	2.07	2.74	43.33
Streptomyces	0.81	0.59	1.25	0.66	1.33	0.44	1.55	1.40	0.22	1.18	1.40	2.14	24.07
Micrococcus I	0.59	0	0.44	0	0.37	0	0	0.66	0.81	0	0.44	0.81	7.92
Micrococcus II	0.81	0.29	0.29	0	0.22	0.44	0	0	0.59	0	0.44	0.37	5.62
Arthrobacter	0.96	0.07	0.51	0	0.22	0.22	0	0.37	0	0	0.66	0.96	6.96
Pseudomonas	0.14	0	0	0	0.07	0	0	0	0	0	0	0.37	1.25
Promicromonospora	0	0.44	0	0	0.14	0	0	0.14	0	0.22	0	0.22	1.77
Cytophaga	0.66	0.22	0.37	0	0.29	0	0	0	0	0.37	0	0.66	4.66
E. coli	0	0.22	0.51	0.22	0	0.14	0	0	0	0	0	0	2.22
Flavobacterium	0.14	0	0.14	0	0	0	0	0	0	0	0	0	0.66
Enterobacter	0	0	0.14	0	0.37	0	0	0	0	0	0	0	1.48
Total	7.18	4.29	4.37	2.88	5.48	1.62	2.51	3.62	2.29	4.37	5.03	8.29	

Table 7 : Showing total and individual species population of earthworm (nos. / m²), values of edaphic factors and heavy metals at Site - II (MD)

Month	Total earthworm	E2	E3	E4	E5	E7	E8	E9	E10	E13	E14	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})
June '01	47	5	4	8	27	0	0	0	0	0	3	28	27	80	92	6.6	0.49
July '01	83	3	7	43	18	0	1	0	0	1	10	31	27	90	98	7.4	0.18
Aug. '01	67	0	0	22	26	0	0	0	0	0	19	29	27	82	96	7.1	0.31
Sept. '01	104	0	0	16	64	0	0	4	1	5	14	33	30	83	90	6.7	0.23
Oct. '01	127	0	0	9	44	4	0	7	7	2	54	27	25	80	90	6.6	0.21
Nov. '01	72	0	0	11	11	3	0	6	3	2	36	28	25	70	82	6.9	0.33
Dec. '01	74	0	0	10	25	3	0	4	0	2	30	22	18	60	80	7.1	1.5
Jan. '02	45	0	4	0	0	6	0	0	0	0	35	20	17	56	65	6.6	0.56
April '02	48	0	6	11	10	0	2	0	0	0	19	33	28	60	72	5.9	0.69
May '02	33	0	10	6	11	0	2	0	0	0	4	37	31	64	70	6.4	0.49
June '02	73	8	0	12	47	0	0	0	0	1	5	30	28	84	96	6.9	0.59
July '02	60	0	0	20	26	0	0	2	2	0	10	27	26	100	100	6.8	0.22
Aug. '02	97	7	0	60	16	1	0	0	0	0	13	31	28	80	96	6.8	0.29
Sept. '02	120	0	0	21	69	0	0	2	4	5	19	32	29	83	92	6.62	0.15

Table 7 : (Contd.)

Month	Total earthworm	E2	E3	E4	E5	E7	E8	E9	E10	E13	E14	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})
Oct. '02	137	0	0	4	47	8	0	10	8	3	57	28	26	84	95	6.9	0.2
Nov. '02	93	0	0	15	19	8	0	3	4	2	42	26	24	85	90	6.4	0.39
Dec. '02	59	0	0	9	14	6	0	0	0	1	29	20	18	76	86	6.9	0.76
Jan. '03	59	0	0	0	1	10	0	0	0	0	48	19	17	75	81	6.3	0.65
Feb. '03	35	0	7	0	0	0	0	0	0	0	28	22	20	75	80	6.31	0.41
Mar. '03	58	0	12	0	8	0	4	0	0	0	34	26	22	72	80	6.8	0.53
April '03	62	0	3	15	15	0	2	0	0	0	27	30	25	63	78	5.66	0.41
May '03	47	0	9	11	15	0	4	0	0	1	7	34	28	72	78	6.4	0.53
June '03	77	12	15	23	18	0	3	0	0	1	5	31	27	73	92	6.5	0.44
July '03	91	11	3	19	41	0	0	0	1	0	16	28	26	95	100	6.86	0.14
Aug. '03	90	9	0	28	31	0	0	4	3	0	15	30	26	88	96	7.3	0.1

Explanations : E2 = *Metaphire posthuma*; E3 = *Perionyx excavatus*; E4 = *Eutyphoeus orientalis*; E5 = *Eutyphoeus incommodus*; E7 = *Drawida nepalensis*; E8 = *Perionyx simlaensis*; E9 = *Polypheretima elongata*; E10 = *Metaphire houlleti*; E13 = *Octochaetona surensis*; E14 = *Drawida papillifer papillifer*

Table 7 : (Contd.)

Month	Total earthworm	E2	E3	E4	E5	E7	E8	E9	E10	E13	E14	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
June '01	47	5	4	8	27	0	0	0	0	0	3	0.72	195	180	470	3	76	42	50
July '01	83	3	7	43	18	0	1	0	0	1	10	1.1	280	236	310	1.25	55	25	30
Aug. '01	67	0	0	22	26	0	0	0	0	0	19	1.72	285	210	320	0.7	45	22	25
Sept. '01	104	0	0	16	64	0	0	4	1	5	14	1.66	372	240	330	1	40	25	25
Oct. '01	127	0	0	9	44	4	0	7	7	2	54	1.73	386	260	470	1.75	42	20	26
Nov. '01	72	0	0	11	11	3	0	6	3	2	36	1.32	360	105	510	2	65	20	26
Dec. '01	74	0	0	10	25	3	0	4	0	2	30	2.57	330	116.2	680	2	65	30	33
Jan. '02	45	0	4	0	0	6	0	0	0	0	35	1.56	310	205	510	2.75	71	31	33
April '02	48	0	6	11	10	0	2	0	0	0	19	1.24	236	195	330	3.75	80	33	50
May '02	33	0	10	6	11	0	2	0	0	0	4	1.1	195	172	430	4	80	40	55
June '02	73	8	0	12	47	0	0	0	0	1	5	0.63	190	222.4	620	4	80	40	60
July '02	60	0	0	20	26	0	0	2	2	0	10	1.24	250	228	350	1.25	62	26	31
Aug. '02	97	7	0	60	16	1	0	0	0	0	13	1.64	320	190.7	350	1	65	26	21
Sept. '02	120	0	0	21	69	0	0	2	4	5	19	1.52	380	252	360	1.75	70	27	32

Table 7 : (Contd.)

Month	Total earthworm	E2	E3	E4	E5	E7	E8	E9	E10	E13	E14	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
Oct. '02	137	0	0	4	47	8	0	10	8	3	57	1.71	404	272	480	1.5	60	15	39
Nov. '02	93	0	0	15	19	8	0	3	4	2	42	1.58	366	94	520	2	49	19	22
Dec. '02	59	0	0	9	14	6	0	0	0	1	29	2.21	350	110	560	2.75	65	30	30
Jan. '03	59	0	0	0	1	10	0	0	0	0	48	1.42	342	195	660	3	80	30	38
Feb. '03	35	0	7	0	0	0	0	0	0	0	28	1.08	252	232	552	3	75	35	50
Mar. '03	58	0	12	0	8	0	4	0	0	0	34	0.9	276	255	560	3	73	44	39
April '03	62	0	3	15	15	0	2	0	0	0	27	1.22	220	232	300	3	85	35	42
May '03	47	0	9	11	15	0	4	0	0	1	7	1.07	188	185	420	3.5	90	42	50
June '03	77	12	15	23	18	0	3	0	0	1	5	0.9	220	210	495	4	90	35	50
July '03	91	11	3	19	41	0	0	0	1	0	16	1.01	235	218	324	1	50	30	30
Aug. '03	90	9	0	28	31	0	0	4	3	0	15	1.44	379	218	180	1	50	30	20

Explanations : *Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E7 = Drawida nepalensis; E8 = Perionyx simlaensis; E9 = Polypheretima elongata; E10 = Metaphire houlleti; E13 = Octochaetona surensis; E14 = Drawida papillifer papillifer*

Table 8 : Showing abundance of total and individual earthworm species obtained per month from Site II: MD (expressed in %)

Month	Total earthworm	E2	E3	E4	E5	E7	E8	E9	E10	E13	E14
June '01	2.52	0.27	0.22	0.43	1.45	–	–	–	–	–	0.16
July '01	4.46	0.16	0.38	2.31	0.97	–	0.05	–	–	0.05	0.54
Aug. '01	3.60	–	–	1.18	1.4	–	–	–	–	–	1.02
Sept. '01	5.59	–	–	0.86	3.44	–	–	0.22	0.05	0.27	0.75
Oct. '01	6.83	–	–	0.48	2.37	0.21	–	0.38	0.38	0.11	2.91
Nov. '01	3.87	–	–	0.59	0.59	0.16	–	0.32	0.16	0.11	1.94
Dec. '01	3.98	–	–	0.54	1.35	0.16	–	0.22	–	0.11	1.62
Jan. '02	2.42	–	0.2	–	–	0.32	–	–	–	–	1.93
April '02	2.58	–	0.32	0.59	0.54	–	0.11	–	–	–	1.02
May '02	1.77	–	0.54	0.32	0.59	–	0.11	–	–	–	0.22
June '02	3.92	0.43	–	0.65	2.53	–	–	–	–	0.05	0.27
July '02	3.22	–	–	1.08	1.4	–	–	0.11	0.11	–	0.54
Aug. '02	5.22	0.38	–	3.23	0.86	0.05	–	–	–	–	0.7
Sept. '02	6.45	–	–	1.13	3.71	–	–	0.11	0.22	0.27	1.02
Oct. '02	7.37	–	–	0.22	2.53	0.43	–	0.54	0.43	0.16	3.07
Nov. '02	5.00	–	–	0.81	1.02	0.43	–	0.16	0.22	0.11	2.26
Dec. '02	3.17	–	–	0.48	0.75	0.32	–	–	–	0.05	1.55
Jan. '03	3.17	–	–	–	0.05	0.54	–	–	–	–	2.58
Feb. '03	1.88	–	0.38	–	–	–	–	–	–	–	1.5
Mar. '03	3.12	–	0.64	–	0.43	–	0.21	–	–	–	1.83
April '03	3.33	–	0.16	0.81	0.81	–	0.11	–	–	–	1.45
May '03	2.52	–	0.48	0.59	0.81	–	0.21	–	–	0.05	0.38
June '03	4.14	0.65	0.8	1.24	0.97	–	0.16	–	–	0.05	0.27
July '03	4.89	0.59	0.16	1.02	2.21	–	–	–	0.05	–	0.86
Aug. '03	4.84	0.48	–	1.51	1.67	–	–	0.22	0.16	–	0.81
TOTAL		2.96	4.3	20.1	32.45	2.63	0.96	2.28	1.78	1.39	31.16

Explanations : *E2 = Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E7 = Drawida nepalensis; E8 = Perionyx simlaensis; E9 = Polypheretima elongata; E10 = Metaphire houlleti; E13 = Octochaetona surensis; E14 = Drawida papillifer papillifer*

Table 9 : Showing total population of Earthworm, Fungi, Bacteria - Actinomycetes, values of edaphic factors and heavy metals at Site - II (MD)

Month	Earthworm (nos. / m^2)	Fungi (no. of CFU X 10^3/gm.)	Bacteria-actinomycetes (no. of CFU X 10^5/gm.)	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})	O C (%)	Available N_2 (Kgha^{-1})	Available P_2O_5 (Kgha^{-1})	Available K_2O (Kgha^{-1})	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
June '01	47	12	35	28	27	80	92	6.6	0.49	0.72	195	180	470	3	76	42	50
July '01	83	36	56	31	27	90	98	7.4	0.18	1.1	280	236	310	1.25	55	25	30
Aug. '01	67	44	63	29	27	82	96	7.1	0.31	1.72	285	210	320	0.7	45	22	25
Sept. '01	104	33	72	33	30	83	90	6.7	0.23	1.66	372	240	330	1	40	25	25
Oct. '01	127	43	51	27	25	80	90	6.6	0.21	1.73	386	260	470	1.75	42	20	26
Nov. '01	72	17	54	28	25	70	82	6.9	0.33	1.32	360	105	510	2	65	20	26
Dec. '01	74	17	43	22	18	60	80	7.1	1.5	2.57	330	116.2	680	2	65	30	33
Jan. '02	45	27	23	20	17	56	65	6.6	0.56	1.56	310	205	510	2.75	71	31	33
April '02	48	23	41	33	28	60	72	5.9	0.69	1.24	236	195	330	3.75	80	33	50
May '02	33	11	26	37	31	64	70	6.4	0.49	1.1	195	172	430	4	80	40	55
June '02	73	13	44	30	28	84	96	6.9	0.59	0.63	190	222.4	620	4	80	40	60
July '02	60	31	71	27	26	100	100	6.8	0.22	1.24	250	228	350	1.25	62	26	31
Aug. '02	97	38	59	31	28	80	96	6.8	0.29	1.64	320	190.7	350	1	65	26	21
Sept. '02	120	32	105	32	29	83	92	6.62	0.15	1.52	380	252	360	1.75	70	27	32

Table 9 : (Contd.)

Month	Earthworm (nos. / m^2)	Fungi (no. of CFU X 10^3/gm.)	Bacteria-actinomycetes (no. of CFU X 10^5/gm.)	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
Oct. '02	137	45	49	28	26	84	95	6.9	0.2	1.71	404	272	480	1.5	60	15	39
Nov. '02	93	23	40	26	24	85	90	6.4	0.39	1.58	366	94	520	2	49	19	22
Dec. '02	59	25	38	20	18	76	86	6.9	0.76	2.21	350	110	560	2.75	65	30	30
Jan. '03	59	26	21	19	17	75	81	6.3	0.65	1.42	342	195	660	3	80	30	38
Feb. '03	35	31	11	22	20	75	80	6.31	0.41	1.08	252	232	552	3	75	35	50
Mar. '03	58	16	39	26	22	72	80	6.8	0.53	0.9	276	255	560	3	73	44	39
April '03	62	18	53	30	25	63	78	5.66	0.41	1.22	220	232	300	3	85	35	42
May '03	47	12	33	34	28	72	78	6.4	0.53	1.07	188	185	420	3.5	90	42	50
June '03	77	21	48	31	27	73	92	6.5	0.44	0.9	220	210	495	4	90	35	50
July '03	91	34	52	28	26	95	100	6.86	0.14	1.01	235	218	324	1	50	30	30
Aug. '03	90	44	75	30	26	88	96	7.3	0.1	1.44	379	218	180	1	50	30	20

Table 10 : Showing abundance of total and individual fungal genera obtained per month from Site II : MD (expressed in %)

Genera	Sept. '02	Oct. '02	Nov. '02	Dec. '02	Jan. '03	Feb. '03	Mar. '03	April '03	May '03	June '03	July '03	Aug. '03	Total
Penicillium	1.04	4.31	2.52	2.38	3.27	0.89	1.63	1.93	1.93	0.74	1.33	2.38	2.82
Aspergillus	0.74	1.04	1.33	1.48	1.63	1.04	0.14	0.89	0.89	0.44	0.14	1.19	1.19
Rhizopus	0	0	0.74	0.29	0.59	0.44	0.29	0.89	0	0.14	0	0	0.59
Mucor	0	0	0.29	0.29	0.44	0.14	0	0.14	0.14	0	0.29	0.59	0.14
Fusarium	0	0	1.19	0	0.14	0	0.14	0	0.29	0	0.14	0.29	0
Trichoderma	0	0	0.44	0.44	0.29	0	0.14	0	0	0	0	0.14	0.29
Cladosporium	0	0	0	0	0	0	0.14	0.14	0.14	0.29	0	0	0.59
Total	1.78	5.35	6.54	4.91	6.39	2.52	2.52	4.01	3.42	1.63	1.93	4.61	5.65

Genera	Sept. '02	Oct. '02	Nov. '02	Dec. '02	Jan. '03	Feb. '03	Mar. '03	April '03	May '03	June '03	July '03	Aug. '03	Total
Penicillium	2.23	4.01	1.93	2.82	2.67	3.12	1.78	1.93	1.33	2.52	2.82	3.27	57.73
Aspergillus	1.33	0.74	1.19	0.14	0.44	0.89	0.14	0.74	0.14	0.44	1.04	1.33	20.83
Rhizopus	0.14	0.14	0.14	0.44	0	0.29	0	0	0.14	0.14	0.74	0.44	6.69
Mucor	0.14	0.29	0.14	0	0.29	0.14	0.14	0	0.14	0	0.14	0.74	4.76
Fusarium	0.29	0.44	0	0	0.29	0	0	0	0	0	0.14	0.44	3.86
Trichoderma	0.44	0.89	0	0	0.14	0	0.14	0	0	0	0.14	0	3.57
Cladosporium	0.14	0.14	0	0.29	0	0.14	0.14	0	0	0	0	0.29	2.52
Total	4.76	6.69	3.42	3.72	3.86	4.61	2.38	2.67	1.78	3.12	5.05	6.54	

Table 11 : Shsowing abundance of total and individual bacteria-actinomycetes genera obtained per month from Site II: MD (expressed in %)

Genera	June '01	July '01	Aug. '01	Sept. '01	Oct. '01	Nov. '01	Dec. '01	Jan. '02	April '02	May '02	June '02	July '02	Aug. '02
Streptomyces	1.41	2.74	2.41	2.57	3.24	2.32	1.83	0.58	1.16	0.91	1.16	2.49	1.91
Arthrobacter	0.41	0.58	0.91	1.58	0.16	1.16	0.41	0.41	1.33	0.74	0.74	1.58	0.66
Bacillus	0.66	0.41	1.08	0.74	0.41	0.74	0.41	0.74	0.91	0.49	0.24	1.49	1.08
Micrococcus I	0.41	0.24	0.41	0.49	0	0	0.24	0.16	0	0	0.58	0.16	0.33
Nocardia	0	0.66	0.41	0.24	0	0	0.66	0	0	0	0.91	0.16	0.24
Azotobacter	0	0	0	0.16	0.41	0	0	0	0	0	0	0	0.49
Pseudomonas	0	0	0	0.16	0	0.24	0	0	0	0	0	0	0.16
Total	2.91	4.65	5.24	5.99	4.24	4.49	3.57	1.91	3.41	2.16	3.66	5.90	4.90

Genera	Sept. '02	Oct. '02	Nov. '02	Dec. '02	Jan. '03	Feb. '03	Mar. '03	April '03	May '03	June '03	July '03	Aug. '03	Total
Streptomyces	3.66	2.91	1.83	1.16	0.91	0.41	1.49	1.74	0.83	3.07	2.07	2.74	47.67
Arthrobacter	1.49	0.58	0.83	0.41	0.49	0.24	0.66	1.08	1.33	0.49	0.49	1.58	20.46
Bacillus	1.74	0.41	0.24	1.58	0.33	0.24	0.58	1.08	0.33	0.24	0.74	0.74	17.80
Micrococcus I	0.74	0	0	0	0	0	0.24	0	0.24	0.16	0.33	0.49	5.32
Nocardia	0.41	0	0	0	0	0	0.24	0	0	0	0.24	0.41	4.65
Azotobacter	0.41	0.16	0	0	0	0	0	0.49	0	0	0.24	0	2.41
Pseudomonas	0.24	0	0.41	0	0	0	0	0	0	0	0.16	0.24	1.66
Total	8.73	4.07	3.32	3.16	1.74	0.91	3.24	4.40	2.74	3.99	4.32	6.23	

Table 12 : Showing total and individual species population of earthworm (nos. / m²), values of edaphic factors and heavy metals at Site - III (BRF)

Month	Total earthworm	E1	E2	E3	E4	E5	E6	E7	E10	E11	E12	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm⁻¹)
June '01	18	0	4	9	5	0	0	0	0	0	0	33	30	80	90	7.5	0.52
July '01	28	17	3	4	4	0	0	0	0	0	0	30	27	90	98	7.2	0.18
Aug. '01	41	24	6	0	11	0	0	0	0	0	0	29	27	80	96	7.1	0.31
Sept. '01	38	22	8	0	8	0	0	0	0	0	0	30	28	78	90	6.3	0.23
Oct. '01	40	19	8	0	13	0	0	0	0	0	0	27	25	80	88	6.5	0.21
Nov. '01	15	13	2	0	0	0	0	0	0	0	0	27	24	70	82	6.7	0.33
Dec. '01	9	9	0	0	0	0	0	0	0	0	0	20	18	66	80	6.83	0.1
Jan. '02	22	0	0	22	0	0	0	0	0	0	0	18	17	70	75	6.7	0.3
April '02	15	0	4	7	4	0	0	0	0	0	0	30	26	70	81	7.3	0.14
May '02	22	0	2	13	7	0	0	0	0	0	0	36	31	64	70	6.8	0.33
June '02	28	3	7	7	11	0	0	0	0	0	0	30	28	84	96	7.5	0.59
July '02	57	28	11	11	7	0	0	0	0	0	0	27	26	95	100	7.5	0.22
Aug. '02	89	51	13	7	8	0	0	4	0	2	4	31	28	90	96	7.2	0.29
Sept. '02	77	43	18	0	6	0	0	7	0	2	1	32	29	72	90	6.62	0.15

Table 12 : (Contd.)

Month	Total earthworm	E1	E2	E3	E4	E5	E6	E7	E10	E11	E12	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})
Oct. '02	57	41	6	0	10	0	0	0	0	0	0	28	26	84	95	6.5	0.2
Nov. '02	19	10	5	0	4	0	0	0	0	0	0	26	24	75	86	7.9	0.28
Dec. '02	16	13	0	0	1	0	0	2	0	0	0	20	18	75	82	6.9	0.16
Jan. '03	25	11	0	0	0	0	0	14	0	0	0	19	17	75	80	6.7	0.3
Feb. '03	15	0	0	14	0	0	0	1	0	0	0	18	20	73	82	6.9	0.22
Mar. '03	32	0	7	23	0	0	0	2	0	0	0	22	19	70	78	7.3	0.19
April '03	35	0	3	19	13	0	0	0	0	0	0	28	25	72	83	7.5	0.14
May '03	23	0	0	9	9	2	3	0	0	0	0	33	28	72	90	7.2	0.21
June '03	69	7	11	14	15	10	6	6	0	0	0	28	25	92	100	7.7	0.4
July '03	110	49	17	0	17	5	7	10	3	0	2	26	26	88	100	7.3	0.13
Aug. '03	110	51	8	2	13	2	11	16	3	1	3	33	28	88	95	7.63	0.1

Explanations : *E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E6 = Eutyphoeus nicholsoni; E7 = Drawida nepalensis; E10 = Metaphire houlleti; E11 = Amynthas corticis; E12 = Octochaetona beatrix*

Table 12 : (Contd.)

Month	Total earthworm	E1	E2	E3	E4	E5	E6	E7	E10	E11	E12	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
June '01	18	0	4	9	5	0	0	0	0	0	0	2.27	280	220	610	2	94	34	35
July '01	28	17	3	4	4	0	0	0	0	0	0	2.54	280	180	590	0.76	80	22	20
Aug. '01	41	24	6	0	11	0	0	0	0	0	0	2.42	300	210	560	1	70	20	16
Sept. '01	38	22	8	0	8	0	0	0	0	0	0	2.1	226	290	580	1	70	28	22
Oct. '01	40	19	8	0	13	0	0	0	0	0	0	1.93	260	296	680	1	65	26	25
Nov. '01	15	13	2	0	0	0	0	0	0	0	0	2.16	170	105	625	2	60	32	32
Dec. '01	9	9	0	0	0	0	0	0	0	0	0	2.07	353	290	590	2	94	36	32
Jan. '02	22	0	0	22	0	0	0	0	0	0	0	1.78	300	270	510	2.75	80	30	35
April '02	15	0	4	7	4	0	0	0	0	0	0	1.46	222	200	420	3	90	30	40
May '02	22	0	2	13	7	0	0	0	0	0	0	2.01	195	286	465	3.25	100	30	40
June '02	28	3	7	7	11	0	0	0	0	0	0	2.8	270	222.4	620	1.55	65	32	22
July '02	57	28	11	11	7	0	0	0	0	0	0	3	290	228	550	0.2	56	18	18
Aug. '02	89	51	13	7	8	0	0	4	0	2	4	2.95	320	190.7	600	0.5	63	25	26
Sept. '02	77	43	18	0	6	0	0	7	0	2	1	2.08	210	210	490	0.7	65	33	21

Table 12 : (Contd.)

Month	Total earthworm	E1	E2	E3	E4	E5	E6	E7	E10	E11	E12	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
Oct. '02	57	41	6	0	10	0	0	0	0	0	0	2.54	260	280	555	1.25	60	25	20
Nov. '02	19	10	5	0	4	0	0	0	0	0	0	2.71	210	180	490	1.5	70	25	24
Dec. '02	16	13	0	0	1	0	0	2	0	0	0	2.01	350	260	610	2	75	30	30
Jan. '03	25	11	0	0	0	0	0	14	0	0	0	2.1	320	200	460	3	86	30	30
Feb. '03	15	0	0	14	0	0	0	1	0	0	0	1.85	312	272	480	3	90	36	38
Mar. '03	32	0	7	23	0	0	0	2	0	0	0	2.3	276	210	480	2.88	100	41	40
April '03	35	0	3	19	13	0	0	0	0	0	0	0.74	252	290	520	2.5	120	32	40
May '03	23	0	0	9	9	2	3	0	0	0	0	1.51	188	220	580	3	132	38	42
June '03	69	7	11	14	15	10	6	6	0	0	0	2.82	286	269.9	680	2.6	105	30	38
July '03	110	49	17	0	17	5	7	10	3	0	2	2.91	353	136	650	0.5	48	26	14
Aug. '03	110	51	8	2	13	2	11	16	3	1	3	3.07	369	136	680	0.8	50	22	16

Explanations : *E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E6 = Eutyphoeus nicholsoni; E7 = Drawida nepalensis; E10 = Metaphire houlleti; E11 = Amynthas corticis; E12 = Octochaetona beatrix*

Table 13 : Showing abundance of total and individual earthworm species obtained per month from Site III: BRF (expressed in %).

Month	Total earthworm	E1	E2	E3	E4	E5	E6	E7	E10	E11	E12
June '01	1.78	–	0.4	0.9	0.5	–	–	–	–	–	–
July '01	2.77	1.7	0.3	0.4	0.4	–	–	–	–	–	–
Aug. '01	4.05	2.4	0.6	–	1.1	–	–	–	–	–	–
Sept. '01	3.76	2.2	0.8	–	0.8	–	–	–	–	–	–
Oct. '01	3.96	1.88	0.8	–	1.29	–	–	–	–	–	–
Nov. '01	1.48	1.29	0.2	–	–	–	–	–	–	–	–
Dec. '01	0.89	0.89	–	–	–	–	–	–	–	–	–
Jan. '02	2.17	–	–	2.18	–	–	–	–	–	–	–
April '02	1.48	–	0.4	0.69	0.4	–	–	–	–	–	–
May '02	2,17	–	0.2	1.29	0.69	–	–	–	–	–	–
June '02	2.77	0.3	0.69	0.69	1.09	–	–	–	–	–	–
July '02	5.64	2.77	1.08	1.08	0.69	–	–	–	–	–	–
Aug. '02	8.81	5.04	1.29	0.69	0.79	–	–	0.4	–	0.19	0.4
Sept. '02	7.62	4.25	1.78	–	0.59	–	–	0.69	–	0.19	0.09
Oct. '02	5.64	4.06	0.59	–	0.99	–	–	–	–	–	–
Nov. '02	1.88	0.99	0.49	–	0.39	–	–	–	–	–	–
Dec. '02	1.58	1.29	–	–	0.1	–	–	0.2	–	–	–
Jan. '03	2.47	1.09	–	–	–	–	–	1.38	–	–	–
Feb. '03	1.48	–	–	1.38	–	–	–	0.09	–	–	–
Mar. '03	3.16	–	0.69	2.28	–	–	–	0.2	–	–	–
April '03	3.46	–	0.3	1.88	1.29	–	–	–	–	–	–
May '03	2.27	–	–	0.89	0.89	0.2	0.3	–	–	–	–
June '03	6.83	0.69	1.08	1.38	1.48	0.99	0.59	0.59	–	–	–
July '03	10.89	4.85	1.68	–	1.68	0.49	0.69	0.99	0.29	–	0.19
Aug. '03	10.89	5.04	0.79	0.2	1.29	0.2	1.09	1.58	0.3	0.09	0.3
TOTAL		40.69	14.2	15.9	16.4	1.88	2.67	6.13	0.59	0.47	0.98

Explanations : *E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E6 = Eutyphoeus nicholsoni; E7 = Drawida nepalensis; E10 = Metaphire houlleti; E11 = Amynthas corticis; E12 = Octochaetona beatrix*

Table 14 : Showing total population of Earthworm, Fungi, Bacteria - Actinomycetes, values of edaphic factors and heavy metals at Site - III (BRF)

Month	Earthworm (nos. / m^2)	Fungi (no. of CFU X 10^3/gm.)	Bacteria-actinomycetes (no. of CFU X 10^5/gm.)	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
June '01	18	16	43	33	30	80	90	7.5	0.52	2.27	280	220	610	2	94	34	35
July '01	28	34	70	30	27	90	98	7.2	0.18	2.54	280	180	590	0.76	80	22	20
Aug. '01	41	57	62	29	27	80	96	7.1	0.31	2.42	300	210	560	1	70	20	16
Sept. '01	38	31	56	30	28	78	90	6.3	0.23	2.1	226	290	580	1	70	28	22
Oct. '01	40	20	49	27	25	80	88	6.5	0.21	1.93	260	296	680	1	65	26	25
Nov. '01	15	19	59	27	24	70	82	6.7	0.33	2.16	170	105	625	2	60	32	32
Dec. '01	9	17	46	20	18	66	80	6.83	0.1	2.07	353	290	590	2	94	36	32
Jan. '02	22	36	44	18	17	70	75	6.7	0.3	1.78	300	270	510	2.75	80	30	35
April '02	15	27	35	30	26	70	81	7.3	0.14	1.46	222	200	420	3	90	30	40
May '02	22	8	22	36	31	64	70	6.8	0.33	2.01	195	286	465	3.25	100	30	40
June '02	28	16	43	30	28	84	96	7.5	0.59	2.8	270	222.4	620	1.55	65	32	22
July '02	57	48	55	27	26	95	100	7.5	0.22	3	290	228	550	0.2	56	18	18
Aug. '02	89	53	68	31	28	90	96	7.2	0.29	2.95	320	190.7	600	0.5	63	25	26
Sept. '02	77	37	53	32	29	72	90	6.62	0.15	2.08	210	210	490	0.7	65	33	21

Table 14 : (Contd.)

Month	Earthworm (nos. / m^2)	Fungi (no. of CFU X 10^3/gm.)	Bacteria-actinomycetes (no. of CFU X 10^5/gm.)	Temp. (upper surface)°C	Temp. (subsoil)°C	Humidity (upper surface) (%)	Humidity (subsoil) (%)	pH	EC (dSm^{-1})	O C (%)	Available N_2 ($Kgha^{-1}$)	Available P_2O_5 ($Kgha^{-1}$)	Available K_2O ($Kgha^{-1}$)	Cd(ppm)	Zn(ppm)	Pb(ppm)	Cu(ppm)
Oct. '02	57	31	44	28	26	84	95	6.5	0.2	2.54	260	280	555	1.25	60	25	20
Nov. '02	19	22	35	26	24	75	86	7.9	0.28	2.71	210	180	490	1.5	70	25	24
Dec. '02	16	23	44	20	18	75	82	6.9	0.16	2.01	350	260	610	2	75	30	30
Jan. '03	25	29	47	19	17	75	80	6.7	0.3	2.1	320	200	460	3	86	30	30
Feb. '03	15	25	27	18	20	73	82	6.9	0.22	1.85	312	272	480	3	90	36	38
Mar. '03	32	15	38	22	19	70	78	7.3	0.19	2.3	276	210	480	2.88	100	41	40
April '03	35	11	31	28	25	72	83	7.5	0.14	0.74	252	290	520	2.5	120	32	40
May '03	23	10	19	33	28	72	90	7.2	0.21	1.51	188	220	580	3	132	38	42
June '03	69	15	57	28	25	92	100	7.7	0.4	2.82	286	269.9	680	2.6	105	30	38
July '03	110	42	75	26	26	88	100	7.3	0.13	2.91	353	136	650	0.5	48	26	14
Aug. '03	110	53	70	33	28	88	95	7.63	0.1	3.07	369	136	680	0.8	50	22	16

Table 15 : Showing abundance of total and individual fungal genera obtained per month from Site III : BRF (expressed in %)

Genera	June '01	July '01	Aug. '01	Sept. '01	Oct. '01	Nov. '01	Dec. '01	Jan. '02	April '02	May '02	June '02	July '02	Aug. '02
Penicillium	1.29	3.02	3.74	2.58	1.72	1.00	1.58	2.30	1.72	0.71	1.58	4.74	4.02
Aspergillus	0.71	0.43	1.72	1.29	0.57	1.29	0.14	0.86	1.15	0	0.14	0.71	1.29
Rhizopus	0.28	0.71	0.71	0.28	0	0.28	0.28	1.15	0.28	0.14	0	0.28	0.57
Mucor	0	0.43	0.28	0.28	0.43	0.14	0	0.14	0.14	0	0.43	0.57	0.14
Fusarium	0	0.14	1.15	0	0.14	0	0.14	0	0.28	0	0.14	0.43	0
Cladosporium	0	0	0	0	0	0	0.14	0.14	0.14	0.28	0	0	0.57
Sclerotium	0	0	0.14	0	0	0	0	0.14	0	0	0	0	0.71
Curvularia	0	0	0	0	0	0	0.14	0.43	0.14	0	0	0	0
Trichoderma	0	0.14	0.43	0	0	0	0	0	0	0	0	0.14	0.28
Total	2.30	4.89	8.20	4.46	2.87	2.73	2.44	5.17	3.88	1.15	2.30	6.90	7.62

Genera	Sept. '02	Oct. '02	Nov. '02	Dec. '02	Jan. '03	Feb. '03	Mar. '03	April '03	May '03	June '03	July '03	Aug. '03	Total
Penicillium	2.15	3.45	2.44	2.73	3.02	2.44	1.72	1.58	1.29	2.01	3.45	4.02	60.43
Aspergillus	1.58	0.28	0.43	0.14	0.28	0.43	0	0	0.14	0	1.00	1.00	15.68
Rhizopus	0.14	0	0.14	0	0	0	0	0	0	0.14	0.71	1.00	7.19
Mucor	0.14	0	0.14	0	0.28	0.14	0.14	0	0	0	0.57	0.71	5.17
Fusarium	0.28	0.43	0	0	0.28	0	0	0	0	0	0.14	0.43	4.02
Cladosporium	0.14	0	0	0.28	0	0.14	0.14	0	0	0	0	0.28	2.30
Sclerotium	0.86	0	0	0.14	0	0	0	0	0	0	0	0	2.01
Curvularia	0	0.28	0	0	0.14	0.43	0	0	0	0	0	0.14	1.72
Trichoderma	0	0	0	0	0.14	0	0.14	0	0	0	0.14	0	1.43
Total	5.32	4.46	3.16	3.30	4.17	3.59	2.15	1.58	1.43	2.15	6.04	7.62	

Table 16 : Showing abundance of total and individual bacteria-actinomycetes genera obtained per month from Site III: BRF (expressed in %)

Genera	June '01	July '01	Aug. '01	Sept. '01	Oct. '01	Nov. '01	Dec. '01	Jan. '02	April '02	May '02	June '02	July '02	Aug. '02
Streptomyces	1.09	2.68	2.26	0.83	2.68	2.34	1.59	0.75	0.92	0.58	1.25	2.34	2.60
Bacillus	1.76	1.34	1.00	0.16	0.75	1.34	0.16	1.59	1.92	0.75	0.92	0.83	1.59
Micrococcus I	0.25	0.92	0.58	1.67	0.16	0	0.41	0.58	0	0	0.41	0	0.41
Micrococcus II	0.16	0.25	0.25	0.33	0.16	0.25	0.25	0	0	0.08	0.25	0.25	0.58
Arthrobacter	0.16	0.41	0.58	1.00	0.25	0.41	0.92	0.50	0.08	0.33	0.16	0.41	0.16
Pseudomonas	0.16	0.16	0.25	0.50	0.08	0.58	0.41	0.08	0	0.08	0.58	0.75	0.16
Promicromonospora	0	0	0.08	0	0	0	0	0.16	0	0	0	0	0
Azotobacter	0	0.08	0.16	0.16	0	0	0.08	0	0	0	0	0	0.16
Total	3.60	5.87	5.20	4.69	4.11	4.94	3.85	3.69	2.93	1.84	3.60	4.61	5.70

Genera	Sept. '02	Oct. '02	Nov. '02	Dec. '02	Jan. '03	Feb. '03	Mar. '03	April '03	May '03	June '03	July '03	Aug. '03	Total
Streptomyces	1.09	1.59	0.92	1.42	0.33	0.08	1.42	0.75	0.25	2.01	3.52	3.85	39.26
Bacillus	1.00	0.41	0.25	0.83	1.25	1.09	0.92	1.51	1.00	0.83	0.25	0.33	23.90
Micrococcus I	0.92	0.16	0.33	0.75	0.67	0.50	0.16	0.16	0	1.42	0.58	0.33	11.49
Micrococcus II	0.16	0.58	0.25	0.08	0.41	0.16	0.33	0.16	0	0.25	0.58	0.16	6.04
Arthrobacter	0.58	0.67	0.58	0.25	0.67	0.16	0.16	0	0.16	0.16	1.09	0.75	10.73
Pseudomonas	0.50	0	0.25	0.16	0.50	0.16	0	0	0.16	0.08	0	0.25	5.95
Promicromonospora	0	0	0.25	0.16	0	0.08	0	0	0	0	0	0.08	0.83
Azotobacter	0.16	0.25	0.08	0	0.08	0	0.16	0	0	0	0.25	0.08	1.76
Total	4.44	3.69	2.93	3.69	3.94	2.26	3.18	2.60	1.59	4.78	6.29	5.87	

Table 17 : Correlations between different variables in Site I / DP

	E1	E2	E3	S1	S2	S3	S4	S5	S6	S7	S8	S9
E1	1.000											
E2	0.137	1.000										
E3	-0.215	0.026	1.000									
S1	0.449*	0.118	0.284	1.000								
S2	0.472*	0.163	0.234	0.965**	1.000							
S3	0.534**	0.305	-0.130	0.140	0.235	1.000						
S4	0.709**	0.249	-0.383	0.179	0.293	0.845**	1.000					
S5	0.445*	0.181	0.306	0.494*	0.470*	0.133	0.228	1.000				
S6	-0.323	-0.252	-0.207	-0.380	-0.367	-0.027	-0.169	-0.811**	1.000			
S7	0.233	0.588**	-0.231	0.178	0.199	0.401*	0.363	-0.115	0.065	1.000		
S8	0.059	0.302	0.226	0.123	0.211	0.556**	0.292	-0.119	0.083	0.214	1.000	
S9	0.487*	0.181	0.078	0.448*	0.494*	0.213	0.251	0.323	-0.381	-0.116	0.186	1.000
S10	0.414*	0.319	-0.257	-0.107	0.019	0.402*	0.564**	0.028	-0.034	0.024	0.055	0.183
S11	-0.218	-0.167	0.192	0.305	0.280	-0.061	-0.263	-0.196	0.124	0.138	0.154	0.320
S12	-0.466*	-0.385	-0.036	-0.462*	-0.532**	-0.331	-0.552**	-0.369	0.422*	-0.449*	-0.137	0.227
S13	-0.549**	-0.424	0.008	-0.581**	-0.637**	-0.528**	-0.641**	-0.390	0.506**	-0.383	-0.212	0.124
S14	-0.148	-0.052	-0.112	-0.511**	-0.540**	-0.280	-0.170	0.164	-0.174	-0.261	-0.327	-0.132

*** Significant at 1% level, * Significant at 5% level.*

Table 17 : (Contd.)

	S10	S11	S12	S13	S14							
E1												
E2												
E3												
S1												
S2												
S3												
S4												
S5												
S6												
S7												
S8												
S9												
S10	1.000											
S11	-0.744**	1.000										
S12	-0.300	0.210	1.000									
S13	-0.226	0.028	0.763**	1.000								
S14	-0.019	-0.273	0.251	0.261	1.000							

*** Significant at 1% level, * Significant at 5% level.*

Table 18 : Correlations between different variables in Site II / MD

	E2	E3	E4	E5	E7	E8	E9	E10	E13	E14	S1	S2
E2	1.000											
E3	0.185	1.000										
E4	0.466*	-0.129	1.000									
E5	0.168	-0.429*	0.176	1.000								
E7	-0.338	-0.392	-0.354	-0.184	1.000							
E8	-0.004	0.831**	-0.113	-0.338	-0.356	1.000						
E9	-0.218	-0.458*	-0.127	0.456*	0.384	-0.352	1.000					
E10	-0.160	-0.419*	-0.081	0.511**	0.394	-0.331	0.876**	1.000				
E13	-0.243	-0.328	-0.006	0.735**	0.133	-0.229	0.577**	0.523**	1.000			
E14	-0.486*	-0.357	-0.433*	-0.087	0.791**	-0.257	0.588**	0.595**	0.201	1.000		
S1	0.218	0.285	0.414*	0.367	-0.641**	0.403*	-0.020	0.029	0.187	-0.591**	1.000	
S2	0.274	0.131	0.449**	0.510**	-0.612**	0.204	0.048	0.139	0.242	-0.576**	0.955**	1.000
S3	0.353	-0.334	0.417*	0.517**	-0.118	-0.376	0.168	0.343	0.151	-0.163	0.119	0.334
S4	0.513**	-0.359	0.576**	0.583**	-0.168	-0.389	0.210	0.317	0.191	-0.196	0.154	0.367
S5	0.276	-0.264	0.364	0.290	-0.041	-0.358	0.266	0.144	0.140	-0.096	-0.088	-0.002
S6	-0.230	0.070	-0.367	-0.363	0.209	0.126	-0.182	-0.436	-0.133	0.074	-0.404	-0.535
S7	-0.410*	-0.554**	0.036	0.111	0.482*	0.424*	0.429*	0.261	0.359	0.481*	-0.394	-0.417*
S8	-0.281	-0.608**	0.056	0.321	0.578**	-0.523**	0.701**	0.658**	0.577**	0.675**	-0.326	-0.266
S9	0.113	0.155	0.051	0.396*	-0.321	0.129	0.078	0.228	0.088	-0.013	0.246	0.296
S10	-0.217	0.040	-0.575**	-0.280	0.532**	-0.038	0.031	-0.081	0.026	0.403*	-0.617**	-0.623**
S11	-0.017	0.598**	-0.506**	-0.431*	-0.031	0.560**	-0.424*	-0.399*	-0.285	-0.167	0.038	-0.093
S12	0.044	0.567**	-0.266	-0.463*	-0.132	0.581**	-0.494*	-0.476*	-0.337	-0.273	0.070	-0.071
S13	0.206	0.631**	-0.264	-0.318	-0.472*	0.604**	-0.682**	-0.679**	-0.455*	-0.540**	0.137	0.014
S14	0.074	0.579**	-0.438*	-0.202	-0.260	0.483*	-0.381	-0.363	-0.258	-0.339	0.212	0.139

*** Significant at 1% level, * Significant at 5% level.*

Table 18 : (Contd.)

	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
E2												
E3												
E4												
E5												
E7												
E8												
E9												
E10												
E13												
E14												
S1												
S2												
S3	1.000											
S4	0.907**	1.000										
S5	0.494*	0.569**	1.000									
S6	-0.639	-0.514**	-0.113	1.000								
S7	-0.169	-0.066	0.241	0.375	1.000							
S8	0.160	0.176	0.341	-0.162	0.696**	1.000						
S9	0.298	0.257	-0.013	-0.531**	-0.344	-0.044	1.000					
S10	-0.357	-0.327	-0.058	0.666**	0.140	0.026	-0.363	1.000				
S11	-0.600**	-0.614**	-0.585**	0.457*	-0.444*	-0.599**	-0.151	0.480*	1.000			
S12	-0.542**	-0.512**	-0.553**	0.391	-0.451*	-0.631**	-0.066	0.330	0.855**	1.000		
S13	-0.354	-0.393	-0.309	0.346	-0.568**	-0.768**	0.042	0.169	0.719**	0.714**	1.000	
S14	-0.365	-0.375	-0.467*	0.310	-0.593**	-0.752**	0.132	0.330	0.866**	0.802**	0.726**	1.000

*** Significant at 1% level, * Significant at 5% level.*

Table 19 : Correlations between different variables in Site III / BRF

	E1	E2	E3	E4	E5	E6	E7	E10	E11	E12	S1	S2
E1	1.000											
E2	0.710**	1.000										
E3	-0.530**	-0.181	1.000									
E4	0.434*	0.586**	-0.120	1.000								
E5	0.110	0.368	0.099	0.539**	1.000							
E6	0.423*	0.340	-0.081	0.562**	0.690**	1.000						
E7	0.510**	0.426*	-0.201	0.110	0.323	0.506**	1.000					
E10	0.568**	0.391	-0.218	0.473*	0.371	0.856**	0.461*	1.000				
E11	0.637**	0.573**	-0.156	0.105	-0.058	0.145	0.596**	0.156	1.000			
E12	0.752**	0.544**	-0.162	0.336	0.151	0.520**	0.567**	0.607**	0.762**	1.000		
S1	0.241	0.363	-0.128	0.547**	0.085	0.218	-0.046	0.129	0.315	0.264	1.000	
S2	0.319	0.472*	-0.169	0.613**	0.093	0.194	-0.085	0.157	0.309	0.276	0.962**	1.000
S3	0.572**	0.558**	-0.166	0.563**	0.422*	0.418*	0.217	0.342	0.177	0.418*	0.222	0.341
S4	0.602**	0.634**	-0.323	0.654**	0.430*	0.414*	0.160	0.331	0.223	0.365	0.349	0.484*
S5	-0.093	0.158	0.283	0.291	0.369	0.398*	0.033	0.263	-0.031	0.187	0.211	0.202
S6	-0.345	-0.064	0.161	0.035	0.082	-0.208	-0.183	-0.333	-0.158	-0.205	0.197	0.236
S7	0.591**	0.536**	-0.301	0.258	0.313	0.404*	0.307	0.404*	0.248	0.466*	0.148	0.225
S8	0.332	0.070	-0.054	0.061	0.180	0.381	0.388	0.473*	0.076	0.407*	-0.460*	-0.412*
S9	-0.378	-0.262	0.303	0.008	-0.071	-0.383	-0.440*	-0.504*	-0.259	-0.452*	-0.193	-0.171
S10	0.379	0.287	-0.317	0.538**	0.470*	0.531**	0.180	0.411*	0.043	0.321	0.203	0.228
S11	-0.815**	-0.679**	0.535**	-0.424*	0.040	-0.175	-0.135	-0.351	-0.425*	-0.484*	-0.269	-0.402*
S12	-0.742**	-0.515**	0.563**	-0.158	0.125	-0.164	-0.231	-0.430*	-0.309	-0.435*	-0.001	-0.125
S13	-0.590**	-0.335	0.398*	-0.405*	-0.018	-0.189	-0.038	-0.279	-0.105	-0.294	-0.235	-0.315
S14	-0.788**	-0.555**	0.640**	-0.381	0.045	-0.240	-0.229	-0.454*	-0.265	-0.378	-0.143	-0.274

*** Significant at 1% level, * Significant at 5% level.*

Table 19 : (Contd.)

	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14
E1												
E2												
E3												
E4												
E5												
E6												
E7												
E10												
E11												
E12												
S1												
S2												
S3	1.000											
S4	0.904**	1.000										
S5	0.384	0.356	1.000									
S6	0.139	0.098	0.196	1.000								
S7	0.730**	0.642**	0.321	0.239	1.000							
S8	0.397*	0.236	0.150	-0.198	0.372	1.000						
S9	-0.245	-0.291	-0.360	0.008	-0.440*	-0.009	1.000					
S10	0.579**	0.600**	0.125	0.139	0.452*	0.328	-0.147	1.000				
S11	-0.682**	-0.739**	-0.032	0.150	-0.619**	-0.238	0.299	-0.489*	1.000			
S12	-0.477*	-0.424*	0.142	0.044	-0.661**	-0.273	0.421*	-0.319	0.774**	1.000		
S13	-0.667**	-0.559**	-0.124	0.086	-0.525**	-0.221	0.214	-0.256	0.703**	0.645**	1.000	
S14	-0.621**	-0.670**	0.028	0.108	-0.667**	-0.319	0.350	-0.389	0.904**	0.851**	0.749**	1.000

*** Significant at 1% level, * Significant at 5% level.*

Table 20 : Correlations between earthworm, fungi, bacteria-actinomycetes population and different soil factors

	Site — I			Site — II			Site — III		
	ET	FT	BT	ET	FT	BT	ET	FT	BT
ET	1.000			1.000			1.000		
FT	0.780**	1.000		0.632*	1.000		0.622*	1.000	
BT	0.553**	0.564**	1.000	0.635**	0.449*	1.000	0.661**	0.717**	1.000
S1	0.501*	0.169	0.128	0.146	-0.070	0.423*	0.326	0.040	0.089
S2	0.522**	0.230	0.251	0.263	0.049	0.509**	0.377	0.124	0.147
S3	0.548**	0.544**	0.479*	0.378	0.517**	0.521**	0.645**	0.544**	0.678**
S4	0.681**	0.665**	0.607**	0.596**	0.528**	0.592**	0.641**	0.508**	0.644**
S5	0.507**	0.256	0.110	0.339	0.402*	0.347	0.194	0.002	0.030
S6	-0.378	-0.084	-0.131	-0.433*	-0.561**	-0.480*	-0.237	-0.245	-0.099
S7	0.262	0.110	0.329	0.336	0.366	0.165	0.572**	0.520**	0.653**
S8	0.122	0.139	0.288	0.684**	0.598**	0.376	0.364	0.458*	0.453*
S9	0.517**	0.320	0.227	0.324	0.458*	0.290	-0.341	-0.390	-0.500*
S10	0.411*	0.491*	0.669**	-0.208	-0.468*	-0.606**	0.433*	0.060	0.503*
S11	-0.208	-0.342	-0.311	-0.605**	-0.777**	-0.616**	-0.623**	-0.691**	-0.760**
S12	-0.511**	-0.301	-0.373	-0.592**	-0.711**	-0.437*	-0.507**	-0.687**	-0.699**
S13	-0.592**	-0.361	-0.348	-0.691**	-0.706**	-0.409*	-0.449*	-0.721**	-0.606**
S14	-0.170	-0.112	-0.164	-0.528**	-0.641**	-0.509**	-0.576**	-0.733**	-0.741**

** Significant at 1% level, * Significant at 5% level.

Explanations : *E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E6 = Eutyphoeus nicholsoni; E7 = Drawida nepalensis; E8 = Perionyx simlaensis; E9 = Polypheretima elongata; E10 = Metaphire houlleti; E11 = Amynthas corticis; E12 = Octochaetona beatrix; E13 = Octochaetona surensis; E14 = Drawida papillifer papillifer.* S1 = Temperature (upper soil surface), S2 = Temperature (subsoil), S3 = Relative humidity (upper soil surface), S4 = Relative humidity (subsoil), S5 = pH of soil, S6 = Soil electrical conductivity, S7 = Soil organic Carbon, S8 = Soil available N_2, S9 = Soil available P_2O_5, S10 = Soil available K_2O, S11 = Soil Cadmium, S12 = Soil Zinc, S13 = Soil Lead, S14 = Soil Copper, ET = Total number of Earthworms, FT = Total number of Fungi, BAT = Total number of Bacteria-actinomycetes

Table 21 : ANOVA for total and individual earthworm species in relation to locality (L) and month (M)

a. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE ET (**Total earthworm species**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	250693.38462	1	250693.38462	25695.25	0.00
L	20996.33333	2	10498.16667	29.11	0.00
M	41970.55556	11	3815.50505	10.58	0.00
ERROR	14062.66667	39	360.58120		

b. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E1 (***Lampito mauritii***)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	54634.25783	1	54634.25783	386.01	0.00
L	64776.46439	2	32388.23219	228.84	0.00
M	18398.60222	11	1672.60020	11.82	0.00
ERROR	5519.83333	39	141.53419		

c. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E2 (***Metaphire posthuma***)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	594.46724	1	594.46724	42.33	0.00
L	160.04558	2	80.02279	5.70	0.01
M	527.55556	11	47.95960	3.42	0.00
ERROR	547.66667	39	14.04274		

d. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E3 (***Perionyx excavatus***)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	1229.40313	1	1229.40313	50.71	0.00
L	386.25926	2	193.12963	7.97	0.00
M	1059.53111	11	96.32101	3.97	0.00
ERROR	945.50000	39	24.24359		

e. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E4 (***Eutyphoeus orientalis***)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	2374.18946	1	2374.18946	58.18	0.00
L	1673.26781	2	836.63390	20.50	0.00
M	1675.55333	11	152.32303	3.73	0.00
ERROR	1591.50000	39	40.80769		

f. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E5 (***Eutyphoeus incommodus***)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	3752.32051	1	3752.32051	139.57	0.00
L	6963.44444	2	3481.72222	129.51	0.00
M	2510.71333	11	228.24667	8.49	0.00
ERROR	1048.50000	39	26.88462		

g. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E6 (***Eutyphoeus nicholsoni***)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	4.62821	1	4.62821	1.27	0.27
M	14.66889	11	1.33354	0.37	0.96
ERROR	141.83333	39	3.63675		

h. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E7 (***Drawida nepalensis***)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	132.51425	1	132.51425	13.34	0.00
L	66.61823	2	33.30912	3.35	0.05
M	123.99778	11	11.27253	1.13	0.36
ERROR	387.50000	39	9.93590		

i. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E8 (***Perionyx simlaensis***)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	5.47578	1	5.47578	24.64	0.00
M	10.79111	11	0.98101	4.41	0.00
ERROR	8.66667	39	0.22222		

j. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E9 (***Polypheretima elongata***)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	20.51282	1	20.51282	24.74	0.00
M	49.03556	11	4.45778	5.38	0.00
ERROR	32.33333	39	0.82906		

k. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E10 (***Metaphire houlleti***)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	15.70513	1	15.70513	24.02	0.00
L	21.87179	2	10.93590	16.73	0.00
M	37.55333	11	3.41394	5.22	0.00
ERROR	25.50000	39	0.65385		

l. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E11 (***Amynthas corticis***)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	0.20513	1	0.20513	2.00	0.17
M	1.33333	11	0.12121	1.18	0.33
ERROR	4.00000	39	0.10256		

m. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E12 (***Octochaetona beatrix***)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	0.62821	1	0.62821	2.07	0.16
M	4.72222	11	0.42929	1.41	0.21
ERROR	11.83333	39	0.30342		

n. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E13 (***Octochaetona surensis***)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	8.01282	1	8.01282	110.29	0.00
M	16.70889	11	1.51899	20.91	0.00
ERROR	2.83333	39	0.07265		

o. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE E14 (***Drawida papillifer papillifer***)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	4754.88462	1	4754.88462	918.78	0.00
M	1935.17556	11	175.92505	33.99	0.00
ERROR	201.83333	39	5.17521		

** < 0.05 significant, # Restricted to single site only.

Table 22 : ANOVA for total and individual fungi genera in relation to locality (L) and month (M)

a. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE FT (***Total fungi genera***)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	54405.12821	1	54405.12821	2356.68	0.00
L	854.36752	2	427.18376	18.50	0.00
M	7655.96889	11	695.99717	30.15	0.00
ERROR	900.33333	39	23.08547		

b. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F1 (***Penicillium* sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	20128.32051	1	20128.32051	948.65	0.00
L	389.10256	2	194.55128	9.17	0.00
M	1518.93556	11	138.08505	6.51	0.00
ERROR	827.50000	39	21.21795		

c. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F2 (***Aspergillus* sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	1670.78205	1	1670.78205	311.52	0.00
L	36.77778	2	18.38889	3.43	0.04
M	451.38889	11	41.03535	7.65	0.00
ERROR	209.16667	39	5.36325		

d. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F3 (***Fusarium* sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	127.35185	1	127.35185	45.78	0.00
L	30.84900	2	15.42450	5.54	0.01
M	95.40222	11	8.67293	3.12	0.00
ERROR	108.50000	39	2.78205		

e. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F4 (***Trichoderma* sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	74.05128	1	74.05128	38.00	0.00
L	26.26496	2	13.13248	6.74	0.00
M	73.22222	11	6.65657	3.42	0.00
ERROR	76.00000	39	1.94872		

f. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F5 (***Rhizopus*** **sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	144.05128	1	144.05128	46.56	0.00
L	5.80342	2	2.90171	0.94	0.40
M	77.50222	11	7.04566	2.28	0.03
ERROR	120.66667	39	3.09402		

g. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F6 (***Cephalosporium*** **sp.**)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	8.89031	1	8.89031	6.00	0.02
M	11.70889	11	1.06444	0.72	0.71
ERROR	57.83333	39	1.48291		

h. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F7 (***Mucor*** **sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	78.66809	1	78.66809	53.98	0.00
L	3.25071	2	1.62536	1.12	0.34
M	46.61111	11	4.23737	2.91	0.01
ERROR	56.83333	39	1.45726		

i. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F8 (***Cladosporium*** **sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	3.56125	1	3.56125	11.90	0.00
L	7.12251	2	3.56125	11.90	0.00
M	18.45778	11	1.67798	5.61	0.00
ERROR	11.66667	39	0.29915		

j. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F9 (***Sclerotium*** **sp.**)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	1.84615	1	1.84615	2.18	0.15
M	7.72000	11	0.70182	0.83	0.61
ERROR	33.00000	39	0.84615		

k. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE F10 (***Curvularia*** **sp.**)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	2.75783	1	2.75783	18.98	0.00
M	4.85778	11	0.44162	3.04	0.01
ERROR	5.66667	39	0.14530		

** < 0.05 significant, # Restricted to single site only.

Table 23 : ANOVA for total and individual bacteria - actinomycetes genera in relation to locality (L) and month (M)

a. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BAT (***Total bacteria-actinomycetes genera***)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	13.96154	1	13.96154	22.22	0.00
L	7.00000	2	3.50000	5.57	0.01
M	14.98000	11	1.36182	2.17	0.04
ERROR	24.50000	39	0.62821		

b. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA1 (***Bacillus* sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	145284.61681	1	145284.61681	928.79	0.00
L	407.33618	2	203.66809	1.30	0.28
M	18191.35333	11	1653.75939	10.57	0.00
ERROR	6100.50000	39	156.42308		

c. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA2 (***Streptomyces* sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	12371.52279	1	12371.52279	374.17	0.00
L	2070.98575	2	1035.49288	31.32	0.00
M	1082.64222	11	98.42202	2.98	0.01
ERROR	1289.50000	39	33.06410		

d. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA3 (***Micrococcus* I**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	19009.12963	1	19009.12963	435.88	0.00
L	879.95157	2	439.97578	10.09	0.00
M	3919.86444	11	356.35131	8.17	0.00
ERROR	1700.83333	39	43.61111		

e. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA4 (***Micrococcus* II**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	939.23647	1	939.23647	83.76	0.00
L	96.97721	2	48.48860	4.32	0.02
M	348.48000	11	31.68000	2.83	0.01
ERROR	437.33333	39	11.21368		

f. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA5 (***Arthrobacter* sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	252.48006	1	252.48006	61.48	0.00
L	127.01140	2	63.50570	15.46	0.00
M	62.33556	11	5.66687	1.38	0.22
ERROR	160.16667	39	4.10684		

g. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA6 (***Pseudomonas* sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	2304.82051	1	2304.82051	171.65	0.00
L	447.85470	2	223.92735	16.68	0.00
M	523.68000	11	47.60727	3.55	0.00
ERROR	523.66667	39	13.42735		

h. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA7 (***Promicromonospora* sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	114.08689	1	114.08689	34.09	0.00
L	59.02849	2	29.51425	8.82	0.00
M	79.86889	11	7.26081	2.17	0.04
ERROR	130.50000	39	3.34615		

i. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA8 (***Cytophaga* sp.**)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	13.40313	1	13.40313	22.56	0.00
M	21.53111	11	1.95737	3.30	0.00
ERROR	23.16667	39	0.59402		

j. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA9 (***E.coli***)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	36.46724	1	36.46724	11.38	0.00
M	67.74667	11	6.15879	1.92	0.07
ERROR	125.00000	39	3.20513		

k. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA10 (***Flavobacterium*** **sp.**)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	12.32051	1	12.32051	38.44	0.00
M	31.16667	11	2.83333	8.84	0.00
ERROR	12.50000	39	0.32051		

l. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA11 (***Enterobacter*** **sp.**)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	1.03846	1	1.03846	9.00	0.00
M	4.42000	11	0.40182	3.48	0.00
ERROR	4.50000	39	0.11538		

m. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA12 (***Azotobacter*** **sp.**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	27.12821	1	27.12821	15.48	0.00
L	14.25641	2	7.12821	4.07	0.02
M	30.22222	11	2.74747	1.57	0.15
ERROR	68.33333	39	1.75214		

n. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE BA13 (***Nocardia*** **sp.**)#

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	27.92023	1	27.92023	7.89	0.01
M	33.52000	11	3.04727	0.86	0.58
ERROR	138.00000	39	3.53846		

** < 0.05 significant, # Restricted to single site only.

Table 24 : ANOVA for abiotic factors in relation to locality (L) and month (M)

a. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S1 (**Upper surface temperature**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	49957.38462	1	49957.38462	19290.47	0.00
L	45.70085	2	22.85043	8.82	0.00
M	1351.55556	11	122.86869	47.44	0.00
ERROR	101.00000	39	2.58974		

b. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S2 (**Subsoil temperature**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	40256.20513	1	40256.20513	25053.06	0.00
L	19.56410	2	9.78205	6.09	0.01
M	1082.74222	11	98.43111	61.26	0.00
ERROR	62.66667	39	1.60684		

c. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S3 (**Upper surface humidity**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	379358.63390	1	379358.63390	12089.05	0.00
L	45.48148	2	22.74074	0.72	0.49
M	4162.13556	11	378.37596	12.06	0.00
ERROR	1223.83333	39	31.38034		

d. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S4 (**Subsoil humidity**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	489487.70513	1	489487.70513	23534.03	0.00
L	13.34188	2	6.67094	0.32	0.73
M	4216.86889	11	383.35172	18.43	0.00
ERROR	811.16667	39	20.79915		

e. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S5 (**pH**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	3180.60266	1	3180.60266	63392.61	0.00
L	2.76723	2	1.38362	27.58	0.00
M	2.84146	11	0.25831	5.15	0.00
ERROR	1.95675	39	0.05017		

f. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S6 (**Electrical conductivity**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	12.15679	1	12.15679	978.63	0.00
L	1.41378	2	0.70689	56.91	0.00
M	1.09786	11	0.09981	8.03	0.00
ERROR	0.48447	39	0.01242		

g. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S7 (**Organic Carbon**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	340.14077	1	340.14077	3810.08	0.00
L	39.68625	2	19.84313	222.27	0.00
M	6.03315	11	0.54847	6.14	0.00
ERROR	3.48168	39	0.08927		

h. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S8 (**Available N_2**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	7284648.32051	1	7284648.32051	5684.89	0.00
L	311603.59829	2	155801.79915	121.59	0.00
M	82296.24667	11	7481.47697	5.84	0.00
ERROR	49974.83333	39	1281.40598		

I. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S9 (**Available P_2O_5**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	3148772.69241	1	3148772.69241	1795.41	0.00
L	8266.82363	2	4133.41181	2.36	0.11
M	62822.51677	11	5711.13789	3.26	0.00
ERROR	68397.79110	39	1753.78952		

j. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S10 (**Available K_2O**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	18069574.25783	1	1.8069574E+7	4780.02	0.00
L	121629.62678	2	60814.81339	16.09	0.00
M	271649.53556	11	24695.41232	6.53	0.00
ERROR	147428.83333	39	3780.22650		

** < 0.05 significant, # Restricted to single site only.

Table 25 : ANOVA for abiotic heavy metals in relation to locality (L) and month (M)

a. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S11 (**Cadmium**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	542.02838	1	542.02838	1256.10	0.00
L	59.69165	2	29.84583	69.16	0.00
M	66.14162	11	6.01287	13.93	0.00
ERROR	16.82915	39	0.43152		

b. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S12 (**Zinc**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	4641693.57407	1	4641693.57407	18248.90	0.00
L	4777141.50712	2	2388570.75356	9390.71	0.00
M	27935.17556	11	2539.56141	9.98	0.00
ERROR	9919.83333	39	254.35470		

c. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S13 (**Lead**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL: GRAND MEAN	1151698.51282	1	1151698.51282	10341.42	0.00
L	1355949.34188	2	677974.67094	6087.72	0.00
M	19454.01333	11	1768.54667	15.88	0.00
ERROR	4343.33333	39	111.36752		

d. UNIVARIATE SUMMARY TABLE FOR DEPENDENT VARIATE S14 (**Copper**)

SOURCE	SUM OF SQUARES	DF	MEAN SQUARE	F	**TAIL PROB.
OVALL. GRAND MEAN	606145.84615	1	606145.84615	1746.99	0.00
L	508734.36752	2	254367 18376	733.12	0.00
M	9326.92000	11	847.90182	2.44	0.02
ERROR	13531.66667	39	346.96581		

** < 0.05 significant, # Restricted to single site only.

Table 26 : Summary table of Step Regression Analysis (Total earthworm population and dominant individual species)

Variables used = ET, E1, E2, E3, E4, E5, E6, E7, E8, E9, E10, E11, E12, E13, E14, S1, S2, S3, S4, S5, S6, S7, S8, S9, S10, S11, S12, S13, S14, FT, F1, F2,F3, F4, F5, F6, F7, F8, F8,F9, F10, BAT, BA1, BA2, BA3, BA4, BA5, BA6, BA7, BA8, BA9, BA10, BA11, BA12, BA13.

a. Dependent variable = ET (**Total earthworm population**).

Independent variables = E1 to E14, S1 to S14, FT to F10, BAT to BA13.

Site I / DP

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	E1	0.9843	0.9689	0.9689	0.9675	715.40	715.40	1
2	E3	0.9946	0.9892	0.0203	0.9882	41.23	1003.98	2

Site II / MD

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	BA3	0.8095	0.6552	0.6552	0.6402	43.71	43.71	1
2	E10	0.8842	0.7818	0.1266	0.7620	12.76	39.41	2
3	E5	0.9109	0.8297	0.0479	0.8054	5.91	34.11	3
4	E7	0.9346	0.8734	0.0437	0.8481	6.91	34.51	4
5	E4	0.9622	0.9258	0.0524	0.9063	13.41	47.42	5
6	E14	0.9819	0.9641	0.0383	0.9522	19.23	80.64	6
7	E3	0.9946	0.9892	0.0250	0.9847	39.32	221.87	7
8	E2	0.9980	0.9960	0.0068	0.9939	26.81	492.29	8
9	E9	0.9996	0.9991	0.0032	0.9986	53.35	1875.17	9
10	E8	0.9998	0.9995	0.0004	0.9992	12.66	3001.33	10

Site III / BRF

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	E1	0.8555	0.7319	0.7319	0.7202	62.78	62.78	1
2	E5	0.9350	0.8742	0.1423	0.8628	24.89	76.44	2
3	E3	0.9725	0.9457	0.0715	0.9380	27.69	122.03	3
4	E4	0.9820	0.9644	0.0186	0.9573	10.47	135.43	4
5	E7	0.9946	0.9892	0.0248	0.9864	43.69	348.35	5
6	E2	0.9978	0.9957	0.0065	0.9942	26.97	691.60	6
7	E6	0.9996	0.9992	0.0036	0.9989	79.47	3188.58	7
8	E12	1.0000	0.9999	0.0007	0.9999	210.38	37179.59	8
9	S3	1.0000	1.0000	0.0000	0.9999	7.73	46950.42	9
10	E10	1.0000	1.0000	0.0000	1.0000	4.02	50765.65	10

b. Dependent variable = E1 (***Lampito mauritii***).

Independent variables = ET, E2 to E14, S1 to S14, FT to F10, BAT to BA13.

Site I / DP

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	ET	0.9843	0.9689	0.9689	0.9675	715.41	715.41	1
2	E3	0.9948	0.9896	0.0208	0.9887	43.96	1047.76	2

Site III / BRF

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	ET	0.8555	0.7319	0.7319	0.7202	62.78	62.78	1
2	E3	0.9401	0.8837	0.1518	0.8731	28.72	83.58	2
3	E5	0.9740	0.9487	0.0650	0.9414	26.60	129.42	3
4	E4	0.9800	0.9605	0.0118	0.9526	5.96	121.46	4
5	E7	0.9917	0.9836	0.0231	0.9792	26.69	227.29	5
6	E2	0.9956	0.9912	0.0076	0.9882	15.52	336.77	6
7	E6	0.9991	0.9981	0.0070	0.9974	64.12	1309.99	7
8	E12	0.9999	0.9999	0.0017	0.9998	183.32	13462.28	8
9	S3	1.0000	0.9999	0.0001	0.9998	8.07	17254.91	9
10	E10	1.0000	0.9999	0.0000	0.9999	3.99	18627.91	10

c. Dependent variable = E2 (***Metaphire posthuma***).

Independent variables= ET to E1, E3 to E14, S1 to S14, FT to F10, BAT to BA13.

Site I / DP

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	S7	0.5887	0.3465	0.3465	0.3181	12.20	12.20	1
2	S11	0.6675	0.4456	0.0991	0.3952	3.93	8.84	2
3	S6	0.7296	0.5324	0.0868	0.4656	3.90	7.97	3
4	F5	0.7957	0.6331	0.1007	0.5597	5.49	8.63	4
5	BA3	0.8186	0.6702	0.0371	0.5834	2.14	7.72	5
6	E1	0.8331	0.6940	0.0238	0.5920	1.40	6.80	6
7	ET	0.8717	0.7598	0.0658	0.6610	4.66	7.68	7
8	BA10	0.8976	0.8056	0.0458	0.7084	3.77	8.29	8
9	S9	0.9327	0.8700	0.0644	0.7920	7.43	11.16	9
10	BA5	0.9487	0.9000	0.0300	0.8286	4.20	12.60	10

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
11	S4	0.9639	0.9290	0.0290	0.8690	5.32	15.47	11
12	S14	0.9772	0.9549	0.0259	0.9098	6.88	21.16	12
13	F2	0.9837	0.9677	0.0128	0.9295	4.37	25.36	13
14	F6	0.9911	0.9824	0.0147	0.9577	8.32	39.81	14
15	BA2	0.9949	0.9899	0.0075	0.9731	6.71	58.82	15
16	S12	0.9968	0.9937	0.0038	0.9811	4.80	78.71	16
17	BA6	0.9973	0.9946	0.0009	0.9814	1.16	75.64	17
18	F7	0.9980	0.9960	0.0014	0.9841	2.18	83.57	18
19	S10	0.9983	0.9967	0.0006	0.9840	0.94	78.49	19
20	S2	0.9985	0.9970	0.0004	0.9822	0.49	67.05	20
21	F3	0.9987	0.9974	0.0004	0.9793	0.45	55.03	21

Site II / MD

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	S4	0.5137	0.2639	0.2639	0.2319	8.24	8.24	1
2	S13	0.6791	0.4612	0.1973	0.4122	8.06	9.42	2
3	P20	0.7500	0.5625	0.1013	0.5000	4.86	9.00	3
4	S11	0.8054	0.6486	0.0862	0.5784	4.91	9.23	4
5	E4	0.8458	0.7154	0.0667	0.6405	4.46	9.55	5
6	BA2	0.8713	0.7591	0.0437	0.6788	3.27	9.46	6
7	BA3	0.8821	0.7782	0.0190	0.6868	1.46	8.52	7
8	E8	0.8906	0.7933	0.0151	0.6899	1.17	7.67	8
9	E13	0.9004	0.8108	0.0175	0.6972	1.39	7.14	9
10	BA6	0.9087	0.8258	0.0150	0.7014	1.21	6.64	10
11	F3	0.9209	0.8481	0.0223	0.7197	1.91	6.60	11
12	F2	0.9307	0.8661	0.0180	0.7323	1.61	6.47	12
13	S5	0.9414	0.8862	0.0201	0.7517	1.94	6.59	13
14	E3	0.9567	0.9153	0.0291	0.7967	3.43	7.72	14
15	ET	0.9758	0.9522	0.0369	0.8725	6.95	11.95	15
16	E10	0.9863	0.9727	0.0205	0.9182	6.02	17.83	16
17	S9	0.9938	0.9877	0.0150	0.9578	8.53	33.08	17
18	S12	0.9957	0.9914	0.0037	0.9655	2.55	38.28	18
19	S10	0.9990	0.9981	0.0067	0.9908	17.56	137.32	19
20	E9	0.9998	0.9995	0.0014	0.9971	11.80	412.90	20
21	S6	1.0000	0.9999	0.0004	0.9995	18.94	2158.08	21
22	F1	1.0000	1.0000	0.0000	0.9997	3.51	3786.00	22

Site III / BRF

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	ET	0.8204	0.6731	0.6731	0.6589	47.35	47.35	1
2	P6	0.8813	0.7766	0.1036	0.7563	10.20	38.25	2
3	F10	0.9112	0.8303	0.0536	0.8060	6.64	34.25	3
4	E12	0.9261	0.8576	0.0273	0.8291	3.84	30.11	4
5	F1	0.9368	0.8776	0.0200	0.8454	3.11	27.25	5
6	S7	0.9478	0.8984	0.0208	0.8645	3.68	26.53	6
7	F2	0.9588	0.9194	0.0210	0.8862	4.42	27.69	7
8	S5	0.9679	0.9368	0.0174	0.9052	4.40	29.63	8
9	F3	0.9737	0.9480	0.0112	0.9168	3.24	30.39	9
10	S6	0.9786	0.9577	0.0097	0.9275	3.22	31.72	10
11	F5	0.9827	0.9657	0.0080	0.9367	3.03	33.29	11
12	S8	0.9875	0.9752	0.0094	0.9503	4.56	39.27	12
13	E1	0.9907	0.9814	0.0063	0.9595	3.72	44.76	13
14	E3	0.9940	0.9881	0.0066	0.9714	5.55	59.15	14
15	BA1	0.9960	0.9921	0.0040	0.9789	4.58	75.29	15
16	S4	0.9980	0.9959	0.0038	0.9877	7.47	121.76	16
17	F4	0.9989	0.9979	0.0020	0.9928	6.56	194.60	17
18	S9	0.9995	0.9989	0.0011	0.9958	5.96	314.35	18
19	S2	0.9998	0.9996	0.0006	0.9979	7.11	601.25	19
20	E10	0.9999	0.9997	0.0002	0.9984	2.52	744.41	20
21	P13	0.9999	0.9998	0.0001	0.9985	1.23	750.26	21
22	BAT	1.0000	1.0000	0.0001	0.9995	6.68	2071.48	22
23	BA6	1.0000	1.0000	0.0000	0.9996	1.70	2670.92	23

d. Dependent variable = E3 (***Perionyx excavatus***).

Independent variables = ET to E2, E4 to E14, S1 to S14, FT to F10, BAT to BA13.

Site I / DP

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	S4	0.3834	0.1470	0.1470	0.1099	3.96	3.96	1
2	BA4	0.5724	0.3277	0.1807	0.2666	5.91	5.36	2
3	S8	0.7331	0.5375	0.2098	0.4714	9.53	8.13	3
4	S5	0.8231	0.6775	0.1401	0.6130	8.69	10.51	4
5	BA9	0.8655	0.7491	0.0716	0.6831	5.42	11.35	5

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
6	F1	0.8894	0.7911	0.0420	0.7215	3.62	11.36	6
7	FT	0.9034	0.8162	0.0251	0.7405	2.32	10.78	7
8	S3	0.9218	0.8498	0.0336	0.7747	3.58	11.32	8
9	S12	0.9449	0.8929	0.0431	0.8287	6.04	13.90	9
10	S7	0.9555	0.9131	0.0201	0.8510	3.24	14.71	10
11	F3	0.9642	0.9297	0.0166	0.8702	3.07	15.62	11
12	S13	0.9716	0.9440	0.0144	0.8881	3.08	16.87	12
13	F2	0.9799	0.9602	0.0162	0.9132	4.48	20.43	13
14	E2	0.9843	0.9689	0.0086	0.9253	2.77	22.23	14
15	E1	0.9913	0.9826	0.0137	0.9537	7.12	33.92	15
16	S6	0.9959	0.9918	0.0091	0.9753	8.85	60.11	16
17	BA2	0.9973	0.9946	0.0029	0.9816	3.75	76.25	17
18	BA1	0.9981	0.9962	0.0016	0.9848	2.46	87.15	18
19	BA7	0.9987	0.9973	0.0011	0.9871	2.08	97.56	19
20	S1	0.9993	0.9987	0.0014	0.9920	4.10	150.39	20
21	BA11	0.9998	0.9996	0.0010	0.9970	7.74	384.88	21
22	F7	1.0000	0.9999	0.0003	0.9991	8.34	1266.23	22
23	S10	1.0000	1.0000	0.0000	0.9992	1.15	1301.15	23
24	S2	1.0000	1.0000	0.0000	0.0000	INF	INF	24

Site II / MD

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	E8	0.8311	0.6907	0.6907	0.6772	51.35	51.35	1
2	BA6	0.8773	0.7696	0.0789	0.7486	7.53	36.74	2
3	E14	0.9131	0.8337	0.0642	0.8100	8.11	35.10	3
4	F2	0.9245	0.8547	0.0209	0.8256	2.88	29.40	4
5	BA12	0.9483	0.8992	0.0445	0.8726	8.39	33.89	5
6	S12	0.9609	0.9233	0.0241	0.8978	5.67	36.13	6
7	E13	0.9671	0.9352	0.0119	0.9086	3.12	35.06	7
8	BAT	0.9703	0.9414	0.0062	0.9122	1.70	32.15	8
9	S9	0.9743	0.9492	0.0077	0.9187	2.28	31.12	9
10	F3	0.9778	0.9561	0.0069	0.9248	2.21	30.50	10
11	F7	0.9807	0.9619	0.0058	0.9296	1.96	29.81	11
12	E2	0.9846	0.9694	0.0075	0.9388	2.96	31.69	12

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
13	E4	0.9879	0.9760	0.0065	0.9475	2.99	34.34	13
14	BA3	0.9901	0.9802	0.0043	0.9526	2.17	35.45	14
15	E5	0.9934	0.9869	0.0066	0.9650	4.53	45.06	15
16	S8	0.9956	0.9913	0.0044	0.9739	4.06	56.87	16
17	S3	0.9970	0.9940	0.0027	0.9794	3.14	68.02	17
18	S4	0.9987	0.9974	0.0035	0.9897	8.07	129.60	18
19	S6	0.9994	0.9988	0.0014	0.9942	5.60	217.18	19
20	F5	0.9996	0.9992	0.0005	0.9955	2.45	266.39	20
21	S2	0.9999	0.9998	0.0005	0.9984	8.13	706.25	21
22	BA2	1.0000	1.0000	0.0002	0.9995	8.14	2279.53	22
23	FT	1.0000	1.0000	0.0000	0.9991	0.09	1188.14	23
24	S7	1.0000	1.0000	0.0000	0.0000	INF	INF	24

Site III / BRF

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	S14	0.6407	0.4105	0.4105	0.3849	16.02	16.02	1
2	S3	0.7056	0.4979	0.0874	0.4523	3.83	10.91	2
3	F5	0.7517	0.5650	0.0671	0.5029	3.24	9.09	3
4	S10	0.7951	0.6321	0.0671	0.5586	3.65	8.59	4
5	F2	0.8171	0.6677	0.0355	0.5802	2.03	7.63	5
6	E2	0.8522	0.7262	0.0585	0.6349	3.85	7.96	6
7	E5	0.8817	0.7773	0.0511	0.6856	3.90	8.48	7
8	E12	0.9092	0.8266	0.0493	0.7400	4.55	9.54	8
9	ET	0.9246	0.8549	0.0283	0.7679	2.93	9.82	9
10	E1	0.9466	0.8960	0.0411	0.8218	5.54	12.07	10
11	S1	0.9598	0.9213	0.0252	0.8547	4.17	13.83	11
12	E7	0.9764	0.9534	0.0321	0.9067	8.25	20.44	12
13	E4	0.9915	0.9831	0.0297	0.9631	19.36	49.22	13
14	E10	0.9969	0.9939	0.0108	0.9854	17.73	116.50	14
15	BA5	0.9985	0.9970	0.0030	0.9919	9.00	196.33	15
16	S4	0.9988	0.9975	0.0006	0.9926	1.91	202.73	16
17	F9	0.9996	0.9992	0.0017	0.9973	14.87	522.40	17
18	F7	0.9997	0.9995	0.0003	0.9979	3.03	636.52	18
19	F4	0.9998	0.9996	0.0002	0.9983	2.33	736.87	19
20	BA12	0.9999	0.9998	0.0001	0.9987	2.63	928.46	20
21	BA6	1.0000	0.9999	0.0001	0.9994	5.48	1874.12	21

e. Dependent variable = E4 (***Eutyphoeus orientalis***).

Independent variables= ET to E3, E5 to E14, S1 to S14, FT to F10, BAT to BA13.

Site II / MD

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	S4	0.5760	0.3318	0.3318	0.3028	11.42	11.42	1
2	BAT	0.7219	0.5212	0.1894	0.4776	8.70	11.97	2
3	S10	0.7999	0.6398	0.1187	0.5884	6.92	12.44	3
4	F7	0.8437	0.7119	0.0720	0.6543	5.00	12.35	4
5	F4	0.8609	0.7412	0.0293	0.6731	2.15	10.88	5
6	S13	0.8801	0.7745	0.0333	0.6994	2.66	10.31	6
7	E10	0.9014	0.8125	0.0380	0.7354	3.45	10.53	7
8	ET	0.9283	0.8617	0.0491	0.7925	5.68	12.46	8
9	S1	0.9471	0.8970	0.0353	0.8351	5.14	14.51	9
10	E5	0.9638	0.9289	0.0319	0.8781	6.28	18.28	10
11	E14	0.9718	0.9444	0.0155	0.8974	3.63	20.08	11
12	E2	0.9825	0.9653	0.0209	0.9306	7.23	27.84	12
13	BA12	0.9915	0.9831	0.0178	0.9631	11.56	49.20	13
14	BA13	0.9954	0.9908	0.0078	0.9780	8.46	77.28	14
15	E3	0.9977	0.9953	0.0045	0.9876	8.72	128.37	15
16	F2	0.9990	0.9980	0.0026	0.9939	10.34	245.84	16
17	F3	0.9993	0.9986	0.0007	0.9953	3.44	302.29	17
18	S8	0.9996	0.9992	0.0006	0.9969	4.46	426.70	18
19	BA2	0.9998	0.9996	0.0003	0.9979	4.00	606.81	19
20	FT	0.9999	0.9997	0.0001	0.9983	2.02	693.80	20
21	S9	0.9999	0.9999	0.0002	0.9989	3.36	1050.69	21
22	S14	1.0000	1.0000	0.0001	0.9998	15.57	5873.68	22

Site III / BRF

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	ET	0.6713	0.4507	0.4507	0.4268	18.87	18.87	1
2	S2	0.7758	0.6019	0.1512	0.5657	8.36	16.63	2
3	E11	0.8751	0.7658	0.1639	0.7323	14.69	22.89	3
4	S9	0.9084	0.8252	0.0594	0.7902	6.80	23.60	4
5	S7	0.9194	0.8453	0.0201	0.8046	2.47	20.76	5

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
6	S10	0.9363	0.8766	0.0313	0.8355	4.57	21.31	6
7	S5	0.9487	0.9001	0.0235	0.8590	4.00	21.89	7
8	E3	0.9576	0.9171	0.0169	0.8756	3.27	22.11	8
9	S6	0.9710	0.9429	0.0259	0.9087	6.80	27.53	9
10	E7	0.9751	0.9508	0.0079	0.9157	2.26	27.08	10
11	E1	0.9781	0.9567	0.0058	0.9200	1.75	26.10	11
12	F4	0.9816	0.9636	0.0069	0.9273	2.29	26.50	12
13	F2	0.9856	0.9714	0.0078	0.9376	3.00	28.76	13
14	F7	0.9906	0.9814	0.0100	0.9553	5.35	37.65	14
15	E2	0.9960	0.9920	0.0106	0.9786	11.88	74.15	15
16	S1	0.9978	0.9956	0.0036	0.9867	6.50	112.42	16
17	F3	0.9982	0.9964	0.0008	0.9875	1.53	112.87	17
18	FT	0.9986	0.9972	0.0009	0.9890	1.92	120.71	18
19	S13	0.9990	0.9981	0.0009	0.9909	2.24	138.11	19
20	BA12	0.9994	0.9988	0.0007	0.9929	2.40	168.01	20

f. Dependent variable = E5 (***Eutyphoeus incommodus***).

Independent variables = ET to E4, E6 to E14, S1 to S14, FT to F10, BAT to BA13.

Site II / MD

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	ET	0.7503	0.5629	0.5629	0.5439	29.62	29.62	1
2	E14	0.8453	0.7145	0.1515	0.6885	11.68	27.53	2
3	E4	0.9506	0.9036	0.1892	0.8899	41.23	65.65	3
4	E3	0.9813	0.9630	0.0593	0.9556	32.03	129.99	4
5	E7	0.9881	0.9763	0.0133	0.9700	10.65	156.31	5
6	E9	0.9930	0.9861	0.0099	0.9815	12.84	213.55	6
7	E2	0.9988	0.9976	0.0115	0.9966	82.09	1019.34	7
8	BA6	0.9992	0.9985	0.0009	0.9977	9.06	1315.72	8
9	E10	0.9995	0.9990	0.0005	0.9984	7.86	1671.66	9
10	FT	0.9998	0.9996	0.0006	0.9993	18.06	3217.06	10
11	E13	0.9998	0.9997	0.0001	0.9994	4.72	3701.97	11
12	F2	0.9999	0.9998	0.0001	0.9995	4.57	4326.82	12
13	F5	0.9999	0.9998	0.0000	0.9996	3.02	4666.96	13

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
14	BA13	0.9999	0.9998	0.0000	0.9996	1.67	4596.78	14
15	BA2	0.9999	0.9999	0.0001	0.9997	4.96	5990.62	15
16	F4	1.0000	0.9999	0.0000	0.9998	4.05	7518.93	16
17	F3	1.0000	1.0000	0.0000	0.9999	5.16	10757.48	17
18	F7	1.0000	1.0000	0.0000	0.9999	3.37	13597.48	18
19	S7	1.0000	1.0000	0.0000	0.9999	3.10	17385.84	19
20	S13	1.0000	1.0000	0.0000	0.9999	2.21	20514.65	20
21	S1	1.0000	1.0000	0.0000	1.0000	3.46	31537.76	21
22	S6	1.0000	1.0000	0.0000	1.0000	1.61	36188.09	22
23	BA12	1.0000	1.0000	0.0000	1.0000	0.26	21806.84	23

Site III / BRF

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	E6	0.6904	0.4767	0.4767	0.4539	20.95	20.95	1
2	E10	0.8118	0.6591	0.1824	0.6281	11.77	21.26	2
3	E2	0.8450	0.7140	0.0549	0.6731	4.03	17.47	3
4	E11	0.9043	0.8177	0.1038	0.7813	11.38	22.43	4
5	F9	0.9374	0.8788	0.0611	0.8469	9.57	27.55	5
6	F3	0.9538	0.9097	0.0310	0.8796	6.17	30.24	6
7	BA5	0.9700	0.9409	0.0312	0.9166	8.98	38.68	7
8	S14	0.9751	0.9508	0.0099	0.9262	3.20	38.64	8
9	BA12	0.9807	0.9618	0.0111	0.9389	4.35	42.01	9
10	BA4	0.9844	0.9690	0.0072	0.9469	3.25	43.81	10
11	E3	0.9861	0.9724	0.0034	0.9491	1.61	41.70	11
12	F5	0.9888	0.9777	0.0052	0.9554	2.82	43.80	12
13	F2	0.9925	0.9851	0.0074	0.9674	5.43	55.76	13
14	F10	0.9940	0.9879	0.0029	0.9711	2.40	58.53	14
15	S8	0.9952	0.9904	0.0025	0.9745	2.34	62.09	15
16	S5	0.9968	0.9937	0.0032	0.9810	4.07	78.30	16
17	BA3	0.9981	0.9963	0.0026	0.9872	4.94	110.27	17
18	BA2	0.9986	0.9972	0.0009	0.9888	1.99	118.92	18

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
19	S4	0.9993	0.9986	0.0014	0.9933	5.09	189.64	19
20	E4	0.9996	0.9991	0.0005	0.9946	2.21	223.89	20
21	BA7	0.9999	0.9998	0.0007	0.9982	8.86	632.49	21
22	BAT	1.0000	1.0000	0.0002	0.9997	19.64	4355.77	22

g. Dependent variable = E7 (***Drawida nepalensis***).

Independent variables = ET to E6, E8 to E14, S1 to S14, FT to F10, BAT to BA13.

Site II / MD

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	E14	0.7914	0.6263	0.6263	0.6100	38.54	38.54	1
2	S9	0.8503	0.7230	0.0968	0.6979	7.69	28.72	2
3	S1	0.8601	0.7398	0.0168	0.7027	1.36	19.91	3
4	F4	0.8688	0.7548	0.0149	0.7057	1.22	15.39	4
5	S11	0.8793	0.7732	0.0184	0.7135	1.54	12.95	5
6	S6	0.8979	0.8063	0.0331	0.7417	3.08	12.49	6
7	F1	0.9114	0.8307	0.0244	0.7610	2.45	11.91	7
8	E3	0.9192	0.8449	0.0142	0.7673	1.46	10.89	8
9	BA2	0.9261	0.8577	0.0128	0.7723	1.35	10.05	9
10	S14	0.9379	0.8796	0.0219	0.7936	2.55	10.23	10
11	S2	0.9428	0.8889	0.0093	0.7950	1.09	9.46	11
12	F5	0.9481	0.8990	0.0100	0.7980	1.19	8.90	12
13	S8	0.9538	0.9098	0.0108	0.8031	1.32	8.53	13
14	E8	0.9607	0.9230	0.0132	0.8151	1.71	8.56	14
15	E10	0.9685	0.9381	0.0151	0.8348	2.19	9.09	15
16	BA12	0.9753	0.9513	0.0132	0.8538	2.17	9.76	16
17	F3	0.9807	0.9617	0.0104	0.8687	1.91	10.34	17
18	E9	0.9860	0.9722	0.0105	0.8889	2.27	11.67	18
19	E2	0.9874	0.9749	0.0027	0.8794	0.53	10.21	19
20	BA13	0.9900	0.9801	0.0052	0.8805	1.04	9.84	20
21	S5	0.9934	0.9869	0.0068	0.8953	1.57	10.77	21
22	BA1	0.9995	0.9991	0.0121	0.9887	25.90	96.83	22
23	E4	0.9998	0.9996	0.0005	0.9902	1.29	106.18	23

Site III / BRF

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	E6	0.6997	0.4896	0.4896	0.4674	22.06	22.06	1
2	E11	0.7625	0.5814	0.0919	0.5434	4.83	15.28	2
3	S2	0.8238	0.6786	0.0971	0.6326	6.35	14.78	3
4	E3	0.8423	0.7094	0.0308	0.6513	2.12	12.21	4
5	S10	0.8738	0.7635	0.0541	0.7013	4.35	12.27	5
6	S6	0.8997	0.8095	0.0459	0.7460	4.34	12.75	6
7	ET	0.9149	0.8371	0.0276	0.7700	2.88	12.48	7
8	F10	0.9236	0.8531	0.0160	0.7796	1.74	11.61	8
9	E2	0.9357	0.8755	0.0224	0.8009	2.70	11.72	9
10	E1	0.9466	0.8960	0.0204	0.8217	2.75	12.06	10
11	F7	0.9575	0.9168	0.0209	0.8465	3.26	13.03	11
12	S5	0.9667	0.9345	0.0176	0.8689	3.23	14.26	12
13	F9	0.9718	0.9444	0.0099	0.8787	1.96	14.37	13
14	BA2	0.9777	0.9559	0.0115	0.8942	2.62	15.49	14
15	E12	0.9823	0.9649	0.0090	0.9065	2.32	16.51	15
16	S8	0.9895	0.9791	0.0141	0.9372	5.40	23.39	16
17	F3	0.9962	0.9924	0.0133	0.9738	12.20	53.56	17
18	BAT	0.9980	0.9959	0.0036	0.9837	5.24	81.49	18
19	BA4	0.9986	0.9972	0.0013	0.9867	2.37	94.92	19
20	F4	0.9991	0.9983	0.0010	0.9895	2.33	114.26	20
21	S1	0.9993	0.9987	0.0004	0.9896	1.03	109.78	21

h. Dependent variable = E9 (***Polypheretima elongata***)

Independent variables= ET to E8, E10 to E14, S1 to S14, FT to F10, BAT to BA13.

Site II / MD

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	E10	0.8769	0.7689	0.7689	0.7589	76.54	76.54	1
2	S6	0.9047	0.8185	0.0496	0.8020	6.01	49.61	2
3	S11	0.9199	0.8462	0.0277	0.8243	3.79	38.53	3
4	BA2	0.9288	0.8626	0.0164	0.8351	2.38	31.39	4

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
5	BA6	0.9412	0.8858	0.0232	0.8557	3.86	29.47	5
6	S3	0.9477	0.8980	0.0122	0.8641	2.16	26.42	6
7	S5	0.9535	0.9092	0.0111	0.8718	2.08	24.31	7
8	BA13	0.9573	0.9164	0.0072	0.8746	1.38	21.92	8
9	S14	0.9631	0.9276	0.0112	0.8842	2.33	21.37	9
10	F3	0.9681	0.9371	0.0095	0.8923	2.12	20.87	10
11	E3	0.9732	0.9470	0.0099	0.9022	2.43	21.13	11
12	BA3	0.9824	0.9651	0.0181	0.9303	6.23	27.69	12
13	E14	0.9876	0.9754	0.0103	0.9463	4.59	33.56	13
14	E7	0.9916	0.9832	0.0078	0.9598	4.67	41.89	14
15	S7	0.9934	0.9868	0.0035	0.9647	2.40	44.73	15
16	BA1	0.9942	0.9885	0.0017	0.9654	1.19	42.89	16
17	BAT	0.9955	0.9910	0.0025	0.9691	1.96	45.35	17
18	S12	0.9969	0.9938	0.0028	0.9751	2.69	53.32	18
19	S4	0.9976	0.9952	0.0014	0.9771	1.51	54.86	19
20	F7	0.9979	0.9958	0.0006	0.9748	0.55	47.43	20
21	S2	0.9979	0.9958	0.0000	0.9666	0.02	34.12	21

I. Dependent variable = E14 (***Drawida papillifer papillifer***)

Independent variables= ET to E13, S1 to S14, FT to F10, BAT to BA13.

Site II / MD

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
1	E7	0.7914	0.6263	0.6263	0.6100	38.54	38.54	1
2	E9	0.8492	0.7211	0.0948	0.6957	7.48	28.44	2
3	S2	0.8871	0.7869	0.0658	0.7565	6.48	25.85	3
4	BA12	0.9128	0.8331	0.0462	0.7998	5.54	24.96	4
5	E2	0.9290	0.8631	0.0299	0.8271	4.16	23.95	5
6	S7	0.9461	0.8951	0.0320	0.8601	5.48	25.59	6
7	F3	0.9574	0.9167	0.0216	0.8824	4.41	26.72	7
8	E3	0.9680	0.9370	0.0203	0.9055	5.16	29.75	8
9	S12	0.9758	0.9522	0.0152	0.9236	4.78	33.23	9

Step No.	Variable Entered	R	Multiple RSQ	Change in RSQ	Adjusted RSQ	F to Enter	F Ratio	DF
10	S11	0.9813	0.9630	0.0107	0.9365	4.05	36.39	10
11	S9	0.9852	0.9706	0.0077	0.9458	3.39	39.04	11
12	S8	0.9875	0.9751	0.0045	0.9503	2.19	39.24	12
13	S6	0.9897	0.9796	0.0044	0.9554	2.38	40.58	13
14	FT	0.9927	0.9855	0.0059	0.9652	4.11	48.61	14
15	E8	0.9957	0.9914	0.0059	0.9771	6.19	69.34	15
16	F4	0.9967	0.9934	0.0020	0.9803	2.44	75.52	16
17	S1	0.9978	0.9956	0.0022	0.9848	3.40	92.61	17
18	S13	0.9990	0.9981	0.0025	0.9924	7.97	175.02	18
19	BAT	0.9994	0.9987	0.0006	0.9939	2.42	205.17	19
20	BA6	0.9995	0.9990	0.0003	0.9942	1.34	208.17	20
21	F1	0.9999	0.9997	0.0007	0.9978	7.58	524.86	21
22	E13	0.9999	0.9998	0.0000	0.9972	0.37	395.71	22
23	S10	0.9999	0.9998	0.0000	0.9946	0.02	192.60	23

Explanations : ET = Total earthworm population, *E1 = Lampito mauritii, E2 = Metaphire posthuma, E3 = Perionyx excavatus, E4 = Eutyphoeus orientalis, E5 = Eutyphoeus incommodus, E6 = Eutyphoeus nicholsoni, E7 = Drawida nepalensis, E8 = Perionyx simlaensis, E9 = Polypheretima elongata, E10 = Metaphire houlleti, E11 = Amynthas corticis, E12 = Octochaetona beatrix, E13 = Octochaetona surensis, E14 = Drawida papillifer papillifer,* S1 = Temperature (upper surface), S2 = Temperature (subsoil), S3 = Humidity (upper surface), S4 = Humidity (subsoil), S5 = pH, S6 = Electrical Conductivity, S7 = Organic Carbon, S8 = Available N_2, S9 = Available P_2O_5, S10 = Available K_2O, S11= Cd, S12 = Zn, S13 = Pb, S14 = Cu, FT = Total fungi genera, *F1 = Penicillium* sp., *F2 = Aspergillus* sp., *F3 = Fusarium* sp., *F4= Trichoderma* sp., *F5 = Rhizopus* sp., *F6 = Cephalosporium* sp., *F7 = Mucor* sp., *F8 = Cladosporium* sp., *F9 = Sclerotium* sp., *F10 = Curvularia* sp., BAT = Total bacteria-actinomycetes genera, *BA1 = Bacillus* sp., *BA2 = Streptomyces* sp., *BA3 = Micrococcus I, BA4 = Micrococcus II, BA5 = Arthrobacter* sp., *BA6 = Pseudomonas* sp., *BA7 = Promicromonospora* sp., *BA8 = Cytophaga* sp., *BA9 = E. coli, BA10 = Flavobacterium* sp., *BA11 = Enterobacter* sp., *BA12 = Azotobacter* sp., *BA13 = Nocardia* sp.

Table 27 : Showing relative abundance of different earthworm species in different sampling sites (%)

Species	Site I: DP	Site II: MD	Site III: BRF	TOTAL
Lampito mauritii	39.73	–	8.3	48.03
Metaphire posthuma	1.45	1.11	2.88	5.44
Perionyx excavatus	0.86	1.61	3.25	5.72
Eutyphoeus orientalis	–	7.53	3.35	10.88
Eutyphoeus incommodus	–	12.18	0.38	12.56
Eutyphoeus nicholsoni	–	–	0.54	0.54
Drawida nepalensis	–	0.98	1.25	2.23
Perionyx simlaensis	–	0.36	–	0.36
Polypheretima elongata	–	0.84	–	0.84
Metaphire houlleti	–	0.66	0.12	0.78
Amynthas corticis	–	–	0.10	0.10
Octochaetona beatrix	–	–	0.20	0.20
Octochaetona surensis	–	0.52	–	0.52
Drawida papillifer papillifer	–	11.69	–	11.69

Table 28 : Showing abundance of earthworm species obtained per month (June 2001 to August 2003) from all sampling sites (expressed in % of total population)

Species	J	J	A	S	O	N	D
Lampito mauritii	1.41	2.48	3.05	2.82	1.97	1.85	1.79
Metaphire posthuma	0.20	0.16	0.24	0.18	0.20	0.10	0.02
Perionyx excavatus	0.26	0.22	0	0	0	0	0
Eutyphoeus orientalis	0.26	0.94	0.66	0.48	0.44	0.22	0.20
Eutyphoeus incommodus	0.54	0.36	0.52	1.29	0.88	0.22	0.50
Eutyphoeus nicholsoni	0	0	0	0	0	0	0
Drawida nepalensis	0	0	0	0	0.08	0.06	0.06
Perionyx simlaensis	0	0.02	0	0	0	0	0
Polypheretima elongata	0	0.0	0	0	0	0	0
Metaphire houlleti	0	0	0	0.02	0.14	0.06	0
Amynthas corticis	0	0	0	0.0	0.002	0.001	0
Octochaetona beatrix	0	0	0	0	0	0	0
Octochaetona surensis	0	0.02	0	0.10	0.04	0.04	0.04
Drawida papillifer papillifer	0.06	0.20	0.38	0.28	1.09	0.72	0.60

Table 28 : (Contd.)

Species	J	A	M	J	J	A	S
Lampito mauritii	1.37	1.55	1.33	1.31	2.84	3.83	3.57
Metaphire posthuma	0.02	0.10	0.08	0.30	0.34	0.48	0.36
Perionyx excavatus	0.52	0.26	0.46	0.14	0.22	0.14	0
Eutyphoeus orientalis	0	0.30	0.26	0.46	0.54	1.37	0.54
Eutyphoeus incommodus	0	0.20	0.22	0.94	0.52	0.32	1.39
Eutyphoeus nicholsoni	0	0	0	0	0	0	0
Drawida nepalensis	0.12	0	0	0	0	0.10	0.14
Perionyx simlaensis	0	0.04	0.04	0	0	0	0
Polypheretima elongata	0	0.0	0.0	0	0	0	0
Metaphire houlleti	0	0	0	0	0.04	0	0.08
Amynthas corticis	0	0	0	0	0.0	0	0.001
Octochaetona beatrix	0	0	0	0	0	0.08	0.02
Octochaetona surensis	0	0	0	0.02	0	0	0.10
Drawida papillifer papillifer	0.70	0.38	0.08	0.10	0.20	0.26	0.38

Species	O	N	D	J	F	M	A
Lampito mauritii	2.36	2.04	1.15	0.24	0.16	0.96	1.39
Metaphire posthuma	0.12	0.12	0.16	0.02	0	0.14	0.06
Perionyx excavatus	0	0	0	0	0.42	0.70	0.82
Eutyphoeus orientalis	0.28	0.38	0.20	0	0	0	0.56
Eutyphoeus incommodus	0.94	0.38	0.28	0.02	0	0.16	0.30
Eutyphoeus nicholsoni	0	0	0	0	0	0	0
Drawida nepalensis	0.16	0.16	0.16	0.48	0.02	0.04	0
Perionyx simlaensis	0	0	0	0	0	0.08	0.04
Polypheretima elongata	0	0	0	0	0	0.0	0.0
Metaphire houlleti	0.16	0.08	0	0	0	0	0
Amynthas corticis	0.0	0.0	0	0	0	0	0
Octochaetona beatrix	0	0	0	0	0	0	0
Octochaetona surensis	0.06	0.04	0.02	0	0	0	0
Drawida papillifer papillifer	1.15	0.84	0.58	0.96	0.56	0.68	0.54

Table 28 : (Contd.)

Species	M	J	J	A
Lampito mauritii	1.01	0.98	2.92	3.53
Metaphire posthuma	0.02	0.76	0.66	0.56
Perionyx excavatus	0.68	0.74	0.06	0.04
Eutyphoeus orientalis	0.40	0.76	0.72	0.82
Eutyphoeus incommodus	0.34	0.56	0.92	0.66
Eutyphoeus nicholsoni	0.06	0.12	0.14	0.22
Drawida nepalensis	0	0.12	0.20	0.32
Perionyx simlaensis	0.08	0.06	0	0
Polypheretima elongata	0.001	0.001	0	0
Metaphire houlleti	0	0	0.08	0.12
Amynthas corticis	0	0	0.001	0.002
Octochaetona beatrix	0	0	0.04	0.06
Octochaetona surensis	0.02	0.02	0	0
Drawida papillifer papillifer	0.14	0.10	0.32	0.30

Table 29 : Showing 'Ubiquitous' and 'Stenoecious' species of earthworm in the study sites

'Stenoecious' species (restricted to)		'Ubiquitous' species (present in two or all sites)
Site II (MD)	**Site III (BRF)**	*Lampito mauritii*
Perionyx simlaensis	*Eutyphoeus nicholsoni*	
Octochaetona surensis	*Amynthas corticis*	*Metaphire posthuma*
Drawida papillifer papillifer	*Octochaetona beatrix*	*Perionyx excavatus*
Polypheretima elongata		*Eutyphoeus orientalis*
		Eutyphoeus incommodus
		Drawida nepalensis
		Metaphire houlleti

Table 30 : Showing relative abundance of different fungal genera in different sampling sites (%)

Genera	Site I (DP)	Site II (MD)	Site III (BRF)	Total
Penicillium sp.	24.09	17.34	18.77	60.21
Aspergillus sp.	6.97	6.25	4.87	18.1
Rhizopus sp.	1.25	2.01	2.23	5.49
Mucor sp.	0.98	1.43	1.60	4.01
Fusarium sp.	2.36	1.16	1.25	4.77
Cladosporium sp.	–	0.75	0.75	1.5
Sclerotium sp.	–	–	0.62	0.62
Curvularia sp.	–	–	0.53	0.53
Trichoderma sp.	2.05	1.07	0.44	3.56
Cephalosporium sp.	1.16	–	–	1.16

Table 31 : Showing abundance of fungal genera obtained per month (June, 2001 to Aug. 2003) from all sampling sites (expressed in % of total population)

Genera	June '01	July '01	Aug. '01	Sept. '01	Oct. '01	Nov. '01	Dec. '01	Jan. '02
Penicillium sp.	1.29	2.81	3.39	3.21	2.27	1.60	1.83	2.32
Aspergillus sp.	0.71	1.11	1.34	1.11	1.07	1.25	0.40	0.84
Rhizopus sp.	0.13	0.49	0.53	0.17	0.17	0.22	0.22	0.62
Mucor sp.	0.08	0.22	0.31	0.17	0.35	0.08	0	0.08
Fusarium sp.	0	0.04	0.89	0.17	0.31	0	0.13	0.13
Trichoderma sp.	0.17	0.13	0.75	0.22	0.08	0	0.04	0
Cladosporium sp.	0	0	0	0	0	0	0.08	0.08
Cephalosporium sp.	0	0	0	0	0	0.08	0.17	0
Sclerotium sp.	0	0	0.04	0	0	0	0	0.04
Curvularia sp.	0	0	0	0	0	0	0.04	0.13

Table 31 : (Contd.)

Genera	April '02	May '02	June '02	July '02	Aug. '02	Sept. '02	Oct. '02	Nov. '02	Dec. '02
Penicillium sp.	2.14	0.93	1.92	2.81	3.35	2.54	3.26	2.45	2.86
Aspergillus sp.	0.67	0.35	0.31	1.07	1.07	1.11	0.49	0.84	0.26
Rhizopus sp.	0.31	0.08	0.08	0.22	0.35	0.17	0.04	0.08	0.13
Mucor sp.	0.13	0	0.31	0.35	0.13	0.22	0.17	0.08	0
Fusarium sp.	0.17	0.04	0.08	0.35	0.22	0.40	0.35	0	0.13
Trichoderma sp.	.08	0	0	0.13	0.35	0.13	0.44	0.08	0
Cladosporium sp.	0.08	0.17	0	0	0.35	0.08	0.04	0	0.17
Cephalosporium sp.	0	0.26	0.04	0	0.13	0	0.31	0	0
Sclerotium sp.	0	0	0	0	0.22	0.26	0	0	0.04
Curvularia sp.	0.04	0	0	0	0	0	0.08	0	0

Genera	Jan. '03	Feb. '03	Mar. '03	April '03	May '03	June '03	July '03	Aug. '03
Penicillium sp.	2.32	2.19	1.74	2.54	1.51	2.36	2.72	3.71
Aspergillus sp.	0.40	0.49	0.22	0.35	0.13	0.44	0.93	1.02
Rhizopus sp.	0	0.08	0.13	0	0.04	0.08	0.58	0.44
Mucor sp.	0.17	0.08	0.13	0	0.04	0	0.31	0.49
Fusarium sp.	0.22	0.31	0.08	0.04	0.04	0	0.22	0.35
Trichoderma sp.	0.08	0.22	0.22	0.04	0	0	0.13	0.17
Cladosporium sp.	0	0.08	0.08	0	0	0	0	0.17
Cephalosporium sp.	0	0	0.08	0	0	0	0	0.04
Sclerotium sp.	0	0	0	0	0	0	0	0
Curvularia sp.	0.04	0.13	0	0	0	0	0	0.04

Table 32 : Showing 'Ubiquitous' and 'Stenoecious' species of fungal genera in the study sites

'Stenoecious' species (restricted to)		'Ubiquitous' species (present in two or all sites)
Site I (DP)	Site III (BRF)	
Cephalosporium sp.	*Sclerotium* sp.	*Penicillium* sp.
	Curvularia sp.	*Aspergillus* sp.
		Fusarium sp.
		Rhizopus sp.
		Mucor sp.
		Trichoderma sp.
		Cladosporium sp.

Table 33 : Showing relative abundance of different bacteria-actinomycetes genera in different sampling sites (%)

Genera	Site I (DP)	Site II (MD)	Site III (BRF)	Total
Bacillus sp.	15.62	5.71	7.61	28.94
Streptomyces sp.	8.68	15.30	12.5	36.48
Micrococcus I	2.85	1.70	3.65	8.22
Micrococcus II	2.02	–	1.92	3.94
Arthrobacter sp.	2.51	6.57	3.41	12.49
Pseudomonas sp.	0.45	0.53	1.89	2.87
Promicromonospora sp.	0.64	–	0.26	0.9
Cytophaga sp.	1.68	–	–	1.68
E. coli	0.80	–	–	0.80
Flavobacterium sp.	0.24	–	–	0.24
Enterobacter sp.	0.53	–	–	0.53
Nocardia sp.	–	1.49	–	1.49
Azotobacter sp.	–	0.77	0.56	1.33

Table 34 : Showing abundance of bacteria-actinomycetes genera obtained per month (June, 2001 to Aug. 2003) from all sampling sites (expressed in % of total population)

Genera	June '01	July '01	Aug. '01	Sept. '01	Oct. '01	Nov. '01	Dec. '01	Jan. '02
Bacillus sp.	1.33	1.44	1.65	1.25	1.14	1.01	0.77	1.04
Streptomyces sp.	0.93	2.21	1.84	1.30	2.21	1.94	1.22	0.50
Micrococcus I	0.34	0.56	0.61	0.69	0.05	0.24	0.29	0.32
Micrococcus II	0.05	0.08	0.26	0.18	0.16	0.18	0.08	0.08
Arthrobacter sp.	0.24	0.53	0.56	0.82	0.16	0.69	0.42	0.37
Pseudomonas sp.	0.13	0.05	0.08	0.26	0.02	0.26	0.13	0.05
Promicromonospora sp.	0	0	0.02	0	0.16	0	0	0.10
Cytophaga sp.	0	0.05	0.21	0	0	0.34	0	0
E. coli	0	0	0.08	0	0	0.18	0.08	0.05
Flavobacterium sp.	0	0	0	0	0	0.08	0.05	0
Enterobacter sp.	0	0	0.02	0	0	0.08	0	0.16
Nocardia sp.	0	0.21	0.13	0.08	0	0	0.21	0
Azotobacter sp.	0	0.02	0.05	0.10	0.13	0	0.02	0

Genera	April '02	May '02	June '02	July '02	Aug. '02	Sept. '02	Oct. '02	Nov. '02	Dec. '02
Bacillus sp.	1.04	0.69	1.14	1.36	1.68	1.97	1.14	0.40	1.49
Streptomyces sp.	0.98	0.64	1.17	2.24	1.68	1.81	1.65	1.33	1.06
Micrococcus I	0.05	0.08	0.40	0.05	0.37	0.74	0.05	0.26	0.24
Micrococcus II	0	0.02	0.18	0.08	0.29	0.34	0.29	0.18	0.02
Arthrobacter sp.	0.50	0.34	0.34	0.72	0.50	1.01	0.42	0.64	0.21
Pseudomonas sp.	0	0.02	0.18	0.32	0.10	0.29	0	0.21	0.05
Promicromonospora sp.	0	0	0	0	0	0	0.16	0.08	0.05
Cytophaga sp.	0	0	0	0.05	0.08	0.24	0.08	0.13	0
E. coli	0	0	0	0	0	0	0.08	0.18	0.08
Flavobacterium sp.	0	0	0	0	0	0.05	0	0.05	0
Enterobacter sp.	0	0	0	0.08	0	0	0	0.05	0
Nocardia sp.	0	0	0.29	0.05	0.08	0.13	0	0	0
Azotobacter sp.	0	0	0	0	0.21	0.18	0.13	0.02	0

Table 34 : (Contd.).

Genera	Jan. '03	Feb. '03	Mar. '03	April '03	May '03	June '03	July '03	Aug. '03
Bacillus sp.	1.38	0.56	0.82	1.20	0.66	1.28	1.06	1.33
Streptomyces sp.	0.88	0.32	1.49	1.30	0.42	2.05	2.29	2.88
Micrococcus I	0.34	0.16	0.13	0.29	0.37	0.50	0.45	0.56
Micrococcus II	0.21	0.21	0.10	0.05	0.21	0.08	0.34	0.18
Arthrobacter sp.	0.45	0.21	0.26	0.48	0.48	0.21	0.74	1.09
Pseudomonas sp.	0.18	0.05	0	0	0.05	0.02	0.05	0.29
Promicromonospora sp.	0.05	0.02	0	0.05	0	0.08	0	0.10
Cytophaga sp.	0.10	0	0	0	0	0.13	0	0.24
E. coli	0	0.05	0	0	0	0	0	0
Flavobacterium sp.	0	0	0	0	0	0	0	0
Enterobacter sp.	0.13	0	0	0	0	0	0	0
Nocardia sp.	0	0	0.08	0	0	0	0.08	0.13
Azotobacter sp.	0.02	0	0.05	0.16	0	0	0.16	0.02

Table 35 : Showing 'Ubiquitous' and 'Stenoecious' species of bacteria-actinomycetes genera in the study sites

'Stenoecious' species (restricted to)		'Ubiquitous' species (present in two or all sites)
Site I (DP)	**Site II (MD)**	
E. coli	*Nocardia* sp.	*Streptomyces* sp.
Flavobacterium sp.		*Bacillus* sp.
Enterobacter sp.		*Arthrobacter* sp.
Cytophaga sp.		*Micrococcus* I
		Micrococcus II
		Pseudomonas sp.
		Promicromonospora sp.
		Azotobacter sp.

Table 36 : Showing values of soil factors, levels of heavy metals, abundance of fungi and bacteria-actinomycetes population in the months when maximum and minimum population of earthworm obtained from respective sites

Sampling Sites	Max^{m}. and min. Earthworm population		Subsoil Temp. (°C)	Subsoil relative humidity (%)	Soil pH	Soil organic carbon (%)
	Month	**%**				
Site I (DP)	Aug.	6.56	28	98	7.16	3.89
	Jan.	1.69	19.5	80	6.9	3.37
Site II (MD)	Oct.	7.1	25.5	92.5	6.75	1.72
	May	2.1	29.5	74	6.4	1.08
Site III (BRF)	Aug.	7.91	27.66	95.66	7.41	2.81
	Dec.	1.23	18	81	6.7	2.04

Table 36 : (Contd.)

Sampling Sites	Max$^{m.}$ and min. Earthworm population		Available Nitrogen (Kg ha^{-1})	Available P_2O_5 (Kg ha^{-1})	Available K_2O (Kg ha^{-1})	Cadmium (ppm)
	Month	%				
Site I (DP)	Aug.	6.56	457	240	709.66	3.33
	Jan.	1.69	375.5	143.5	569	2.87
Site II (MD)	Oct.	7.1	395	266	475	1.62
	May	2.1	191.5	178.5	425	3.75
Site III (BRF)	Aug.	7.91	329.6	178.9	613.3	0.76
	Dec.	1.23	351.5	275	600	2

Sampling Sites	Max$^{m.}$ and min. Earthworm population		Zinc (ppm)	Lead (ppm)	Copper (ppm)	Fungi population (%)	Bacteria-actinomycetes population (%)
	Month	%					
Site I (DP)	Aug.	6.56	593.33	286.66	193.33	6.04	6.31
	Jan.	1.69	660	400	260	2.92	3.99
Site II (MD)	Oct.	7.1	51	17.5	32.5	6.54	4.1
	May	2.1	85	41	52.5	1.7	2.45
Site III (BRF)	Aug.	7.91	43.6	22.3	19.3	7.81	5.59
	Dec.	1.23	84.5	33	31	2.87	3.77

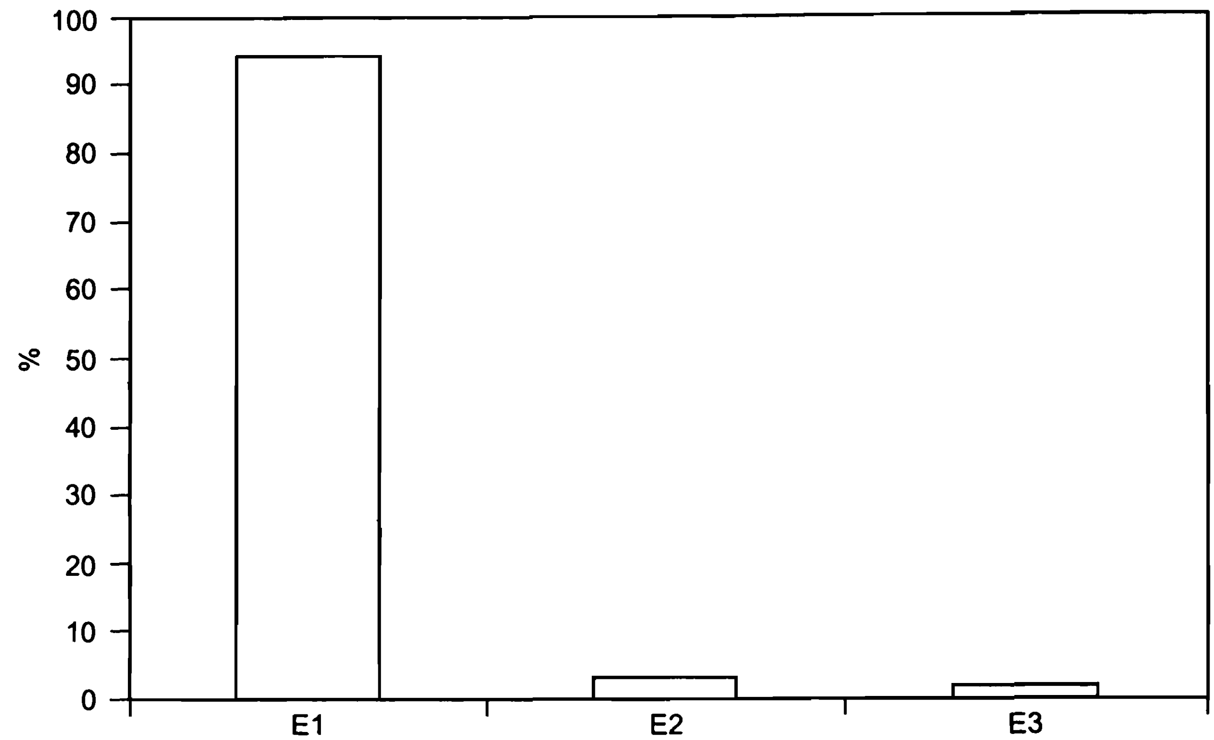


Fig. 1 : Showing composition of earthworm community at Site I (DP)

Explanations : E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus

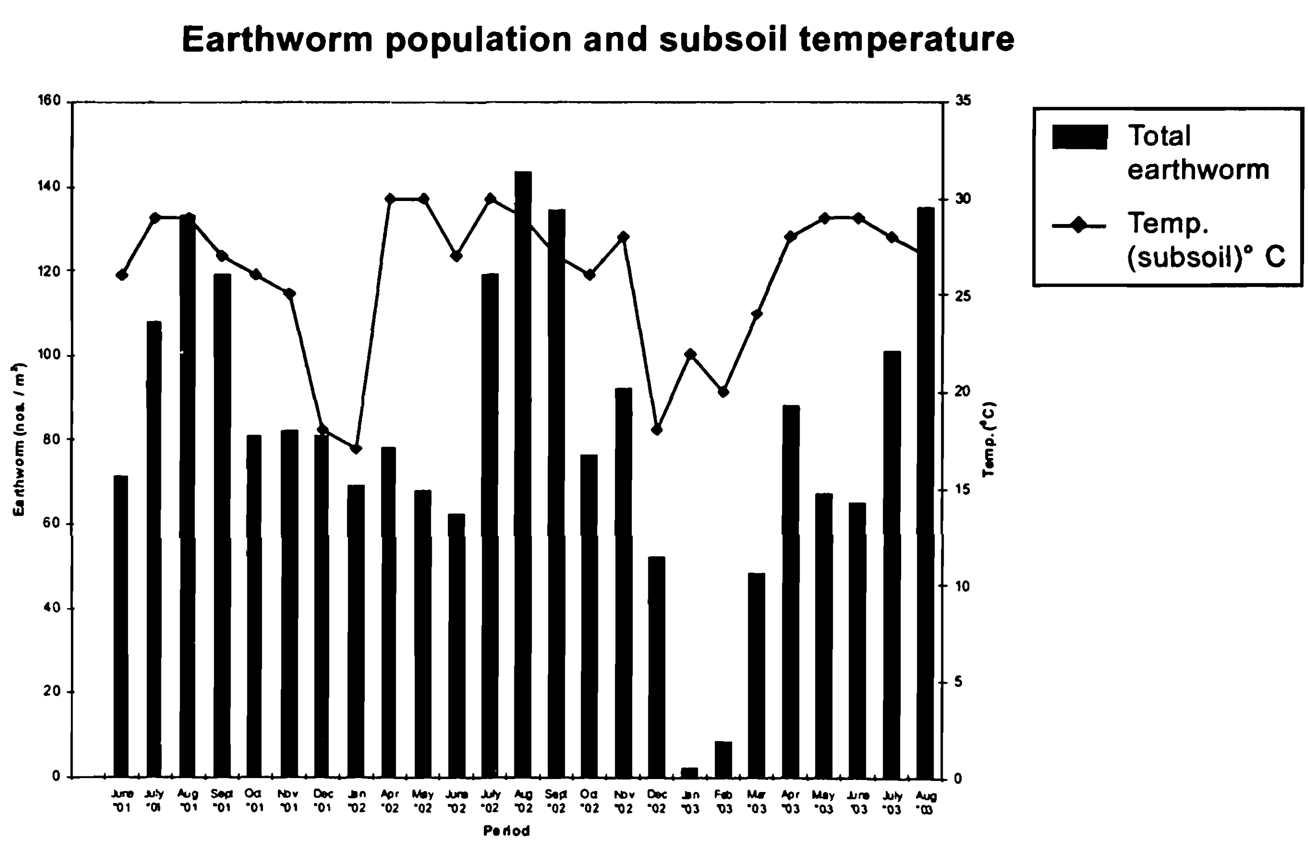


Fig. 2 : Showing monthly fluctuations of earthworm population and subsoil temperature at Site I (DP)

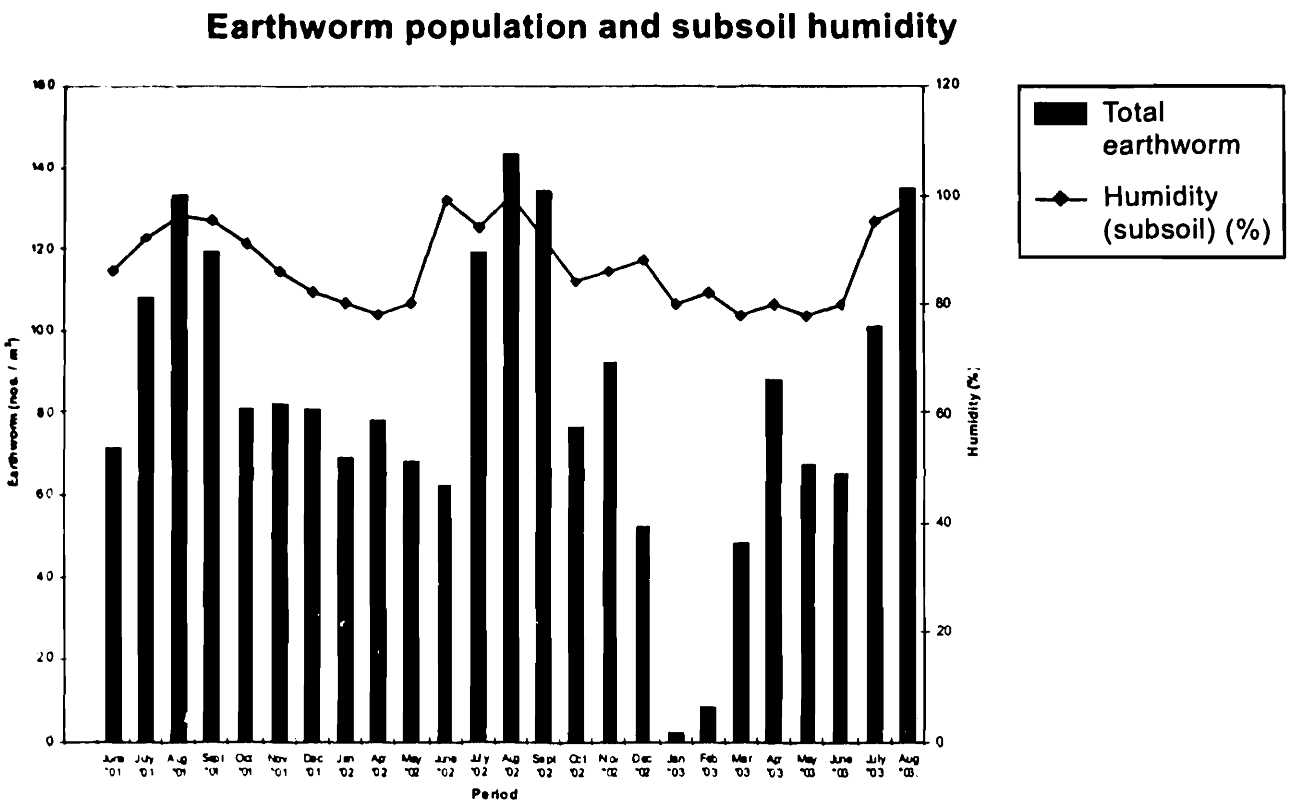


Fig. 3 : Showing monthly fluctuations of earthworm population and subsoil relative humidity at Site I (DP)

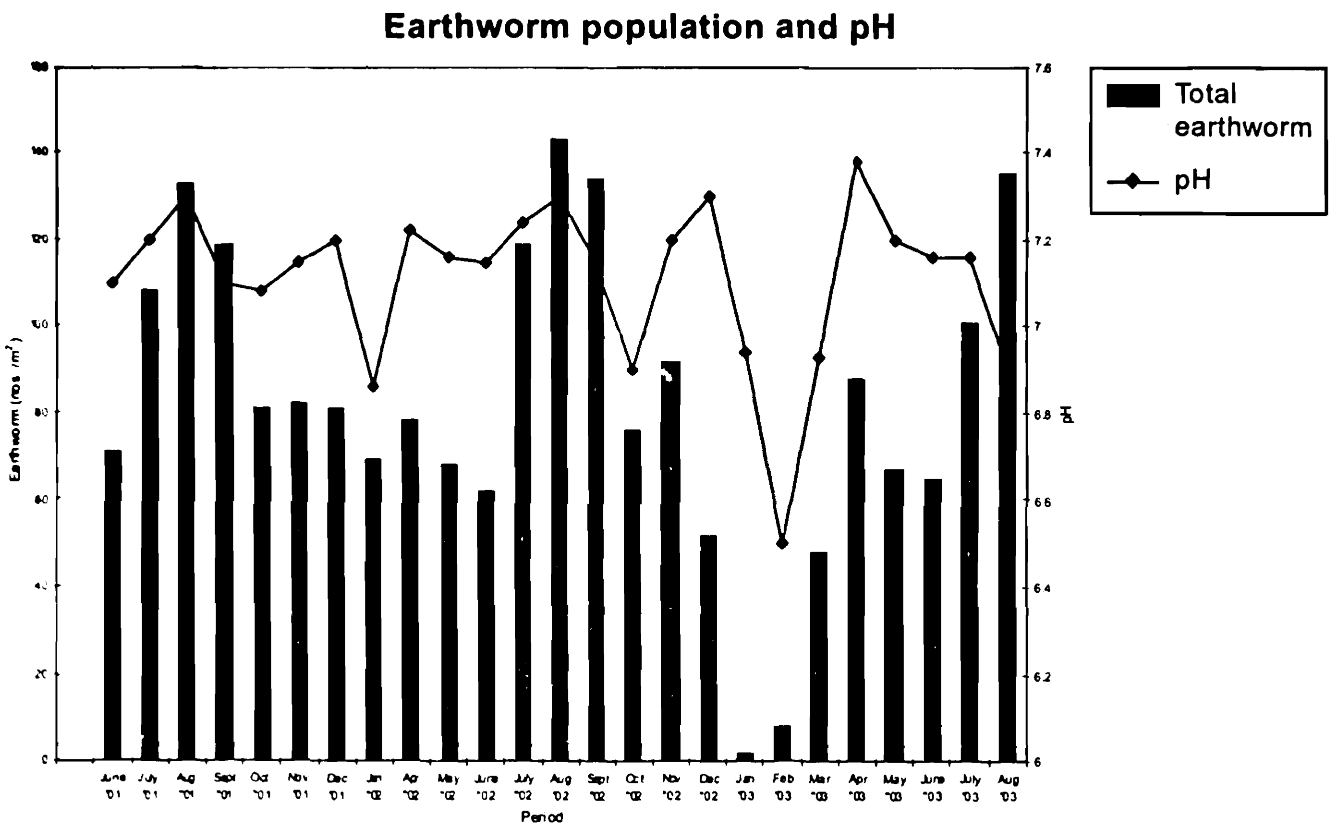


Fig. 4 : Showing monthly fluctuations of earthworm population and pH at Site I (DP)

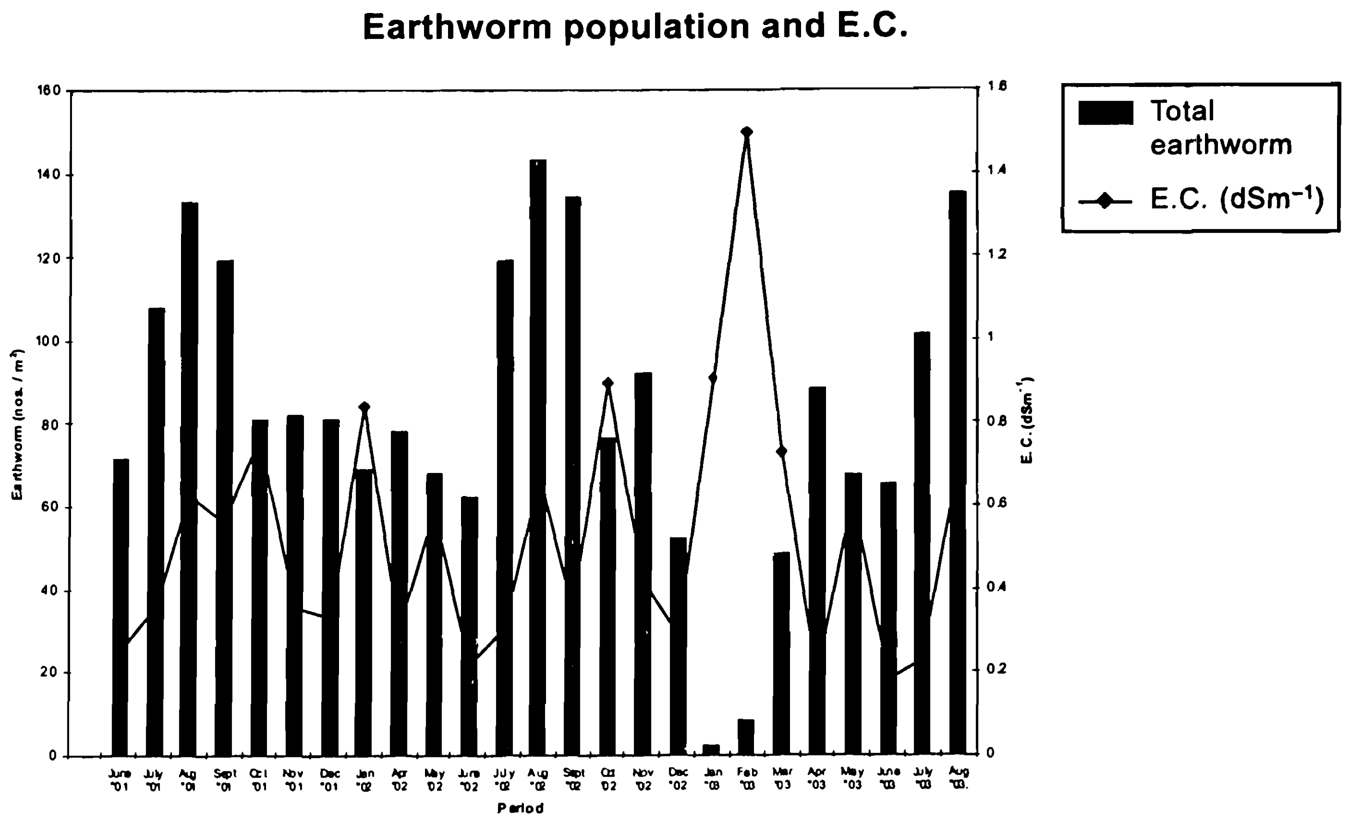


Fig. 5 : Showing monthly fluctuations of earthworm population and electrical conductivity at Site I (DP)

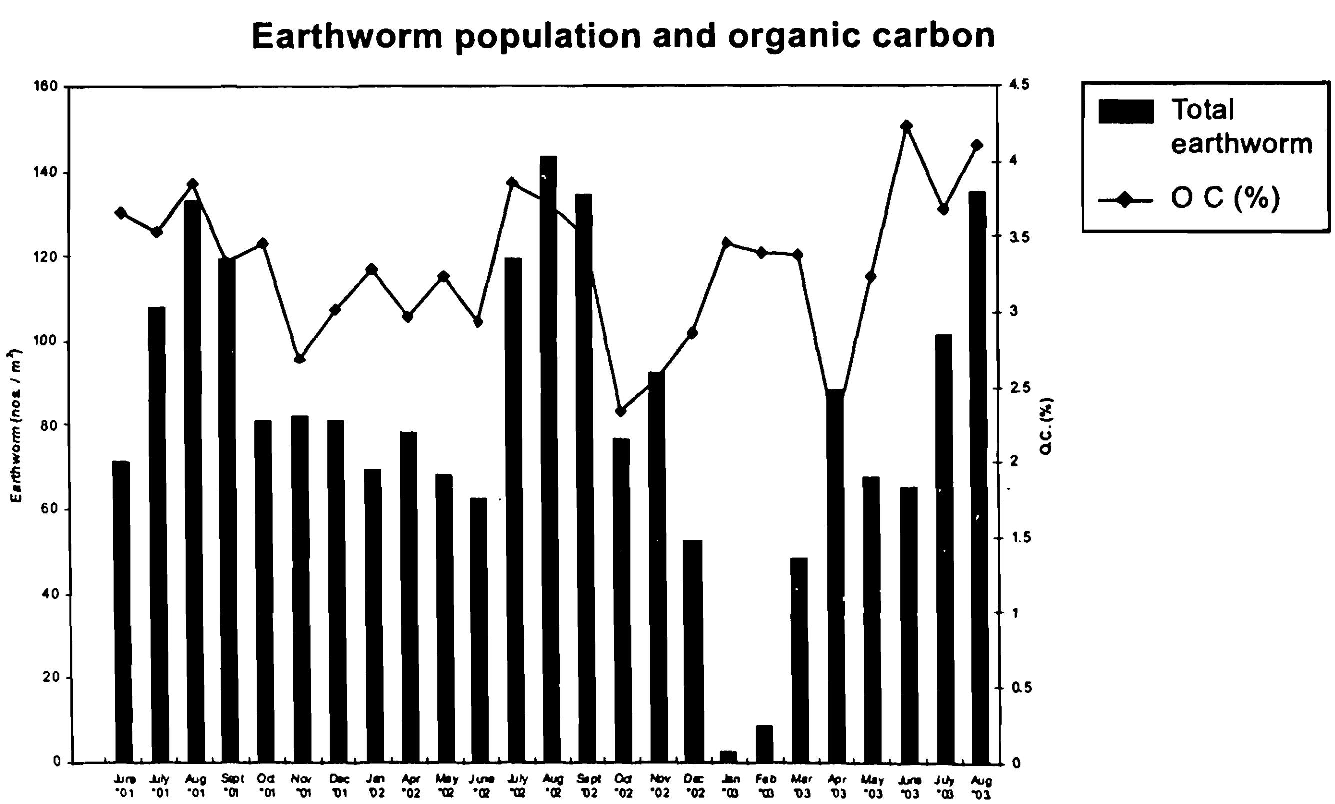


Fig. 6 : Showing monthly fluctuations of earthworm population and organic Carbon at Site I (DP)

Earthworm population and available N_2

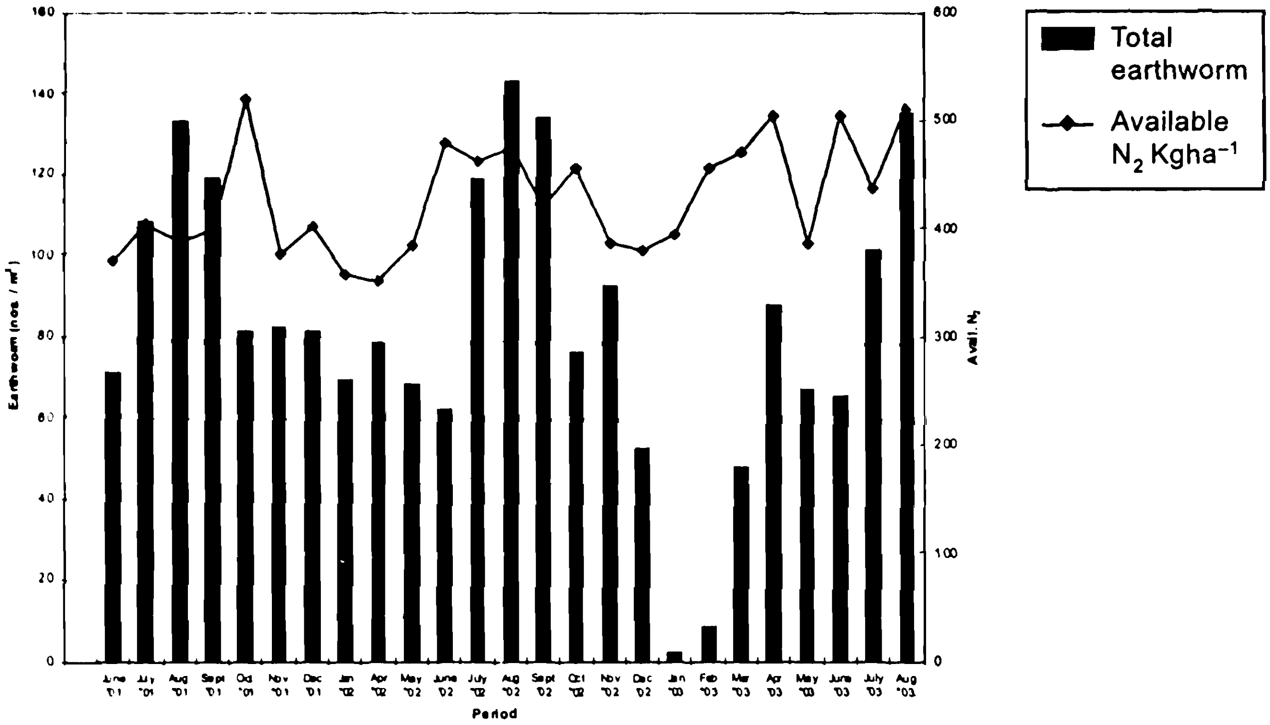


Fig. 7 : Showing monthly fluctuations of earthworm population and available Nitrogen at Site I (DP)

Fluctuation of total earthworm population and soil available P_2O_5

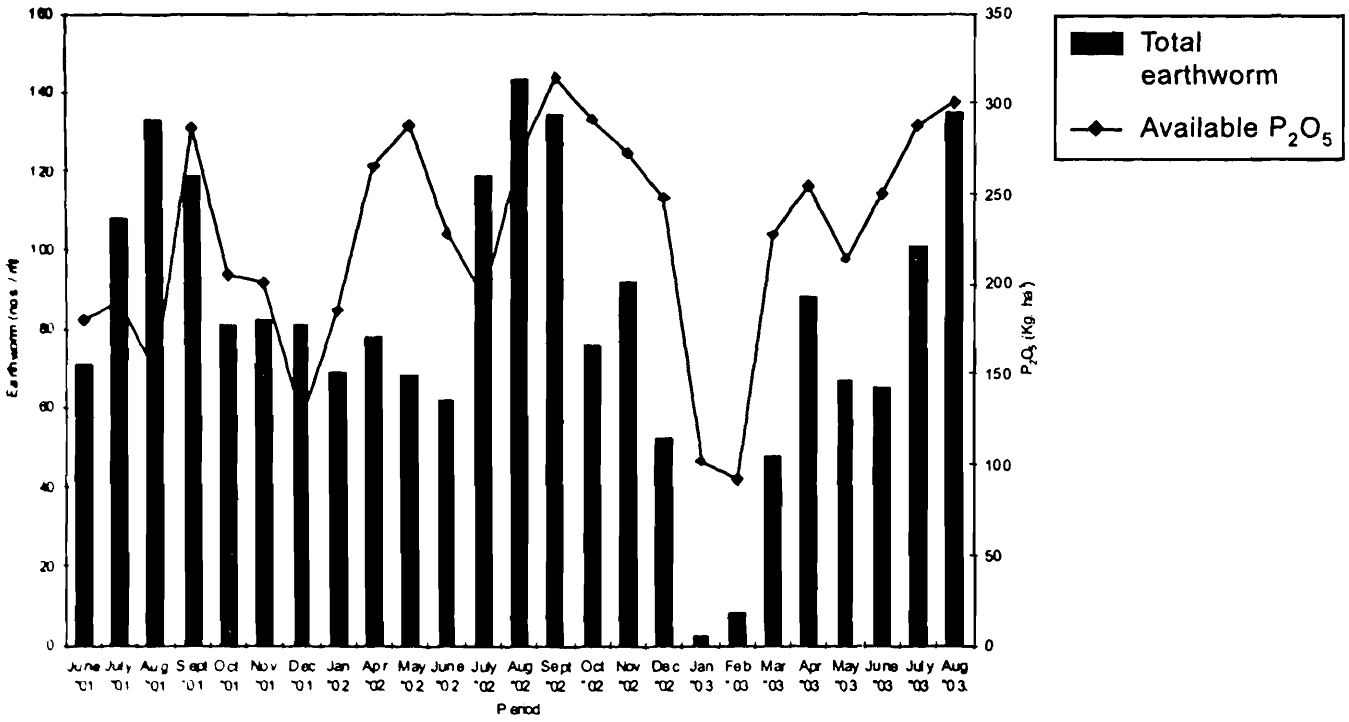


Fig. 8 : Showing monthly fluctuations of earthworm population and available P_2O_5 at Site I (DP)

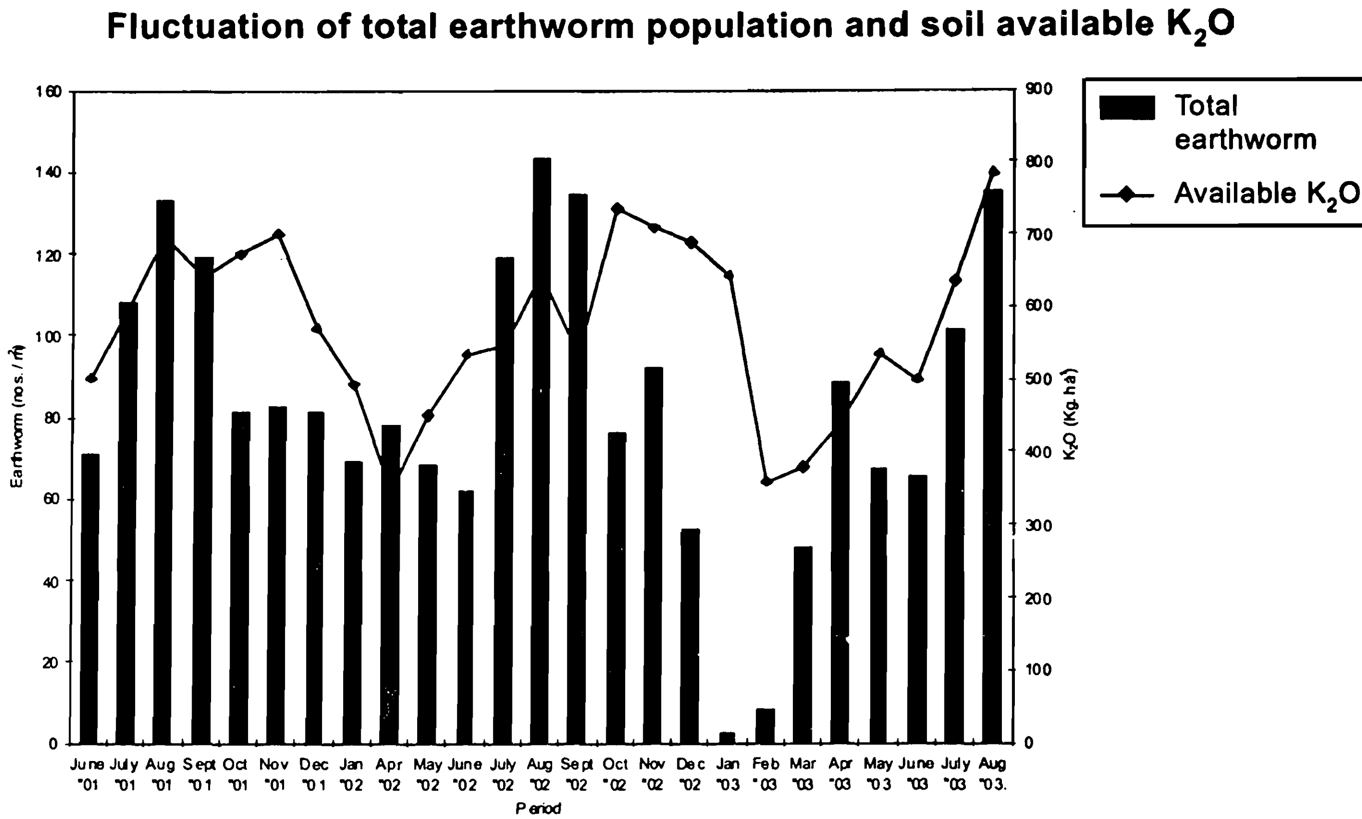


Fig. 9 : Showing monthly fluctuations of earthworm population and available K_2O at Site I (DP)

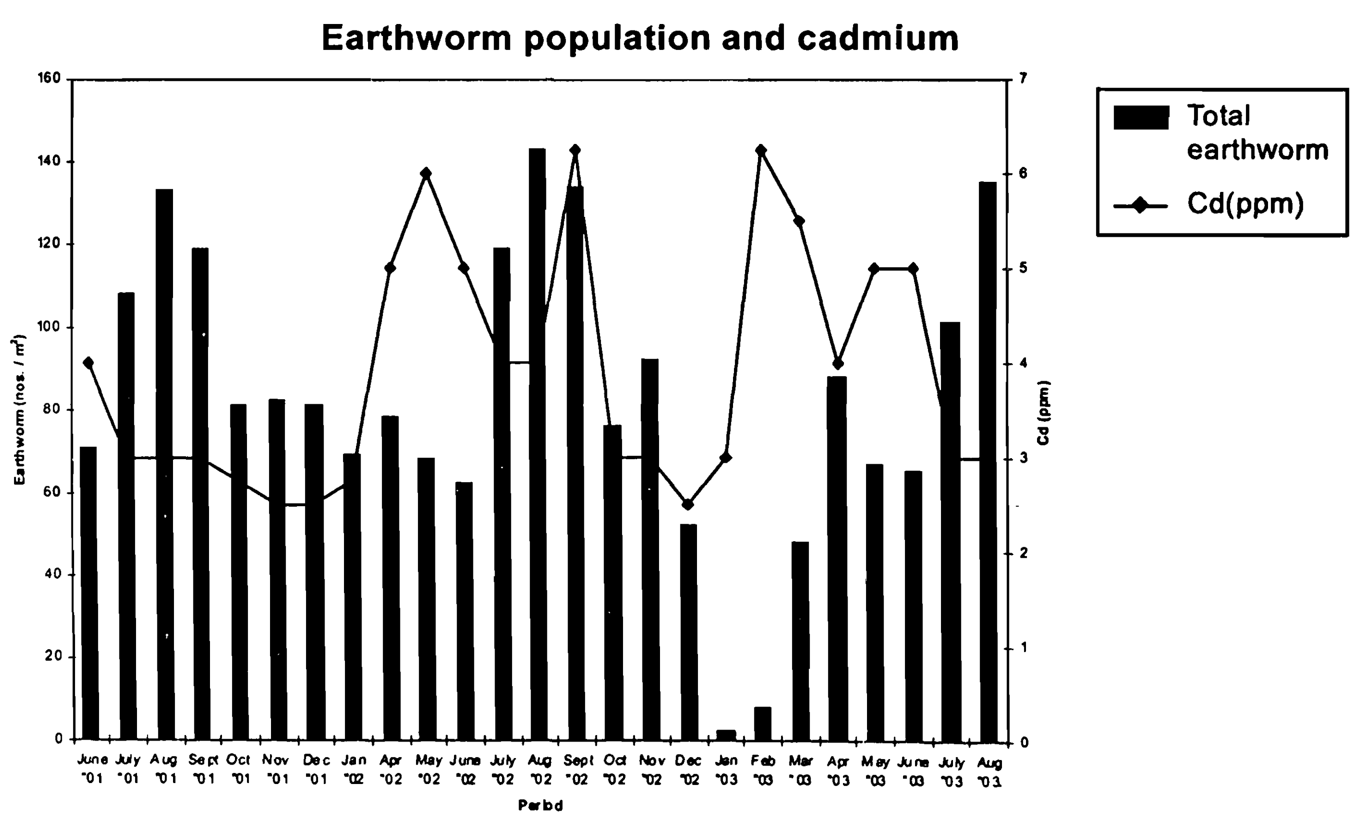


Fig. 10 : Showing monthly fluctuations of earthworm population and Cadmium at Site I (DP)

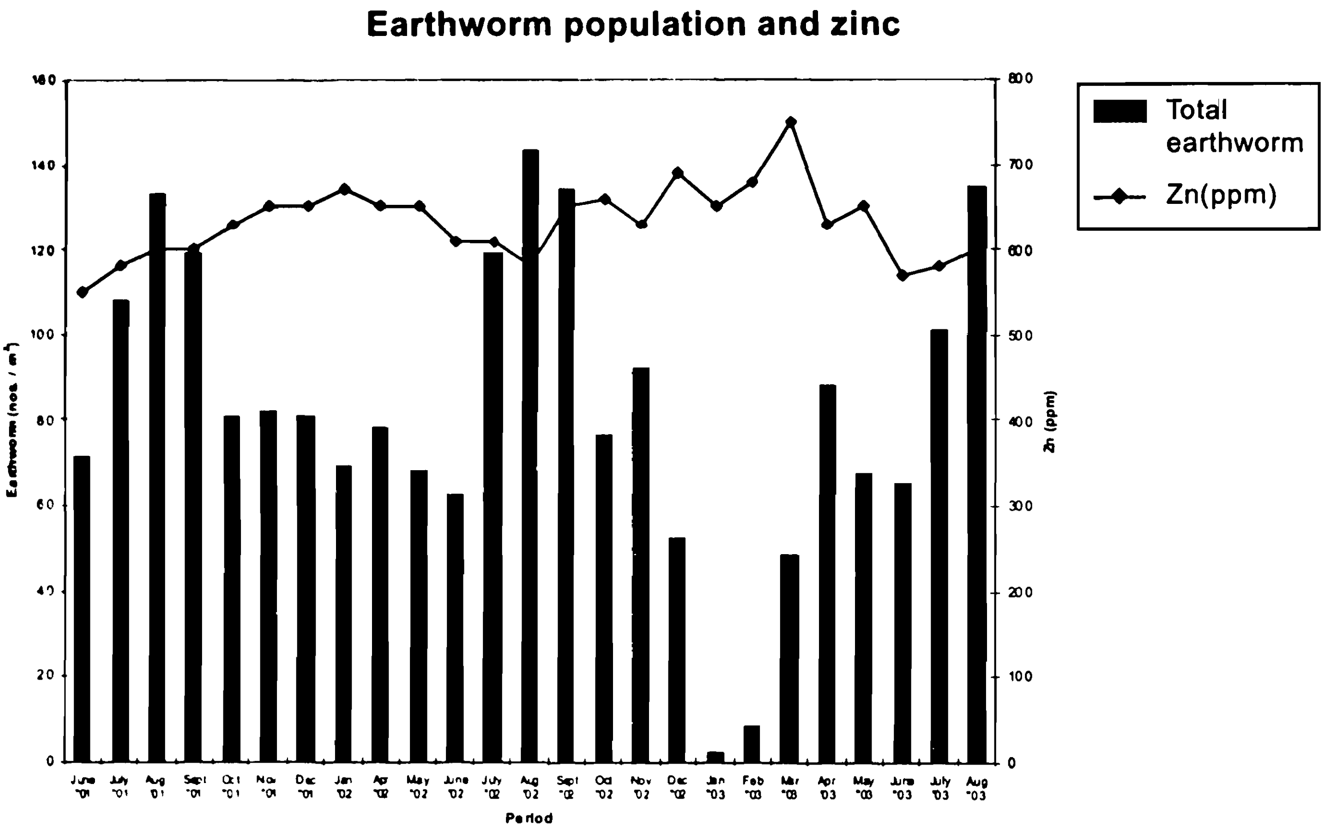


Fig. 11 : Showing monthly fluctuations of earthworm population and Zinc at Site I (DP)

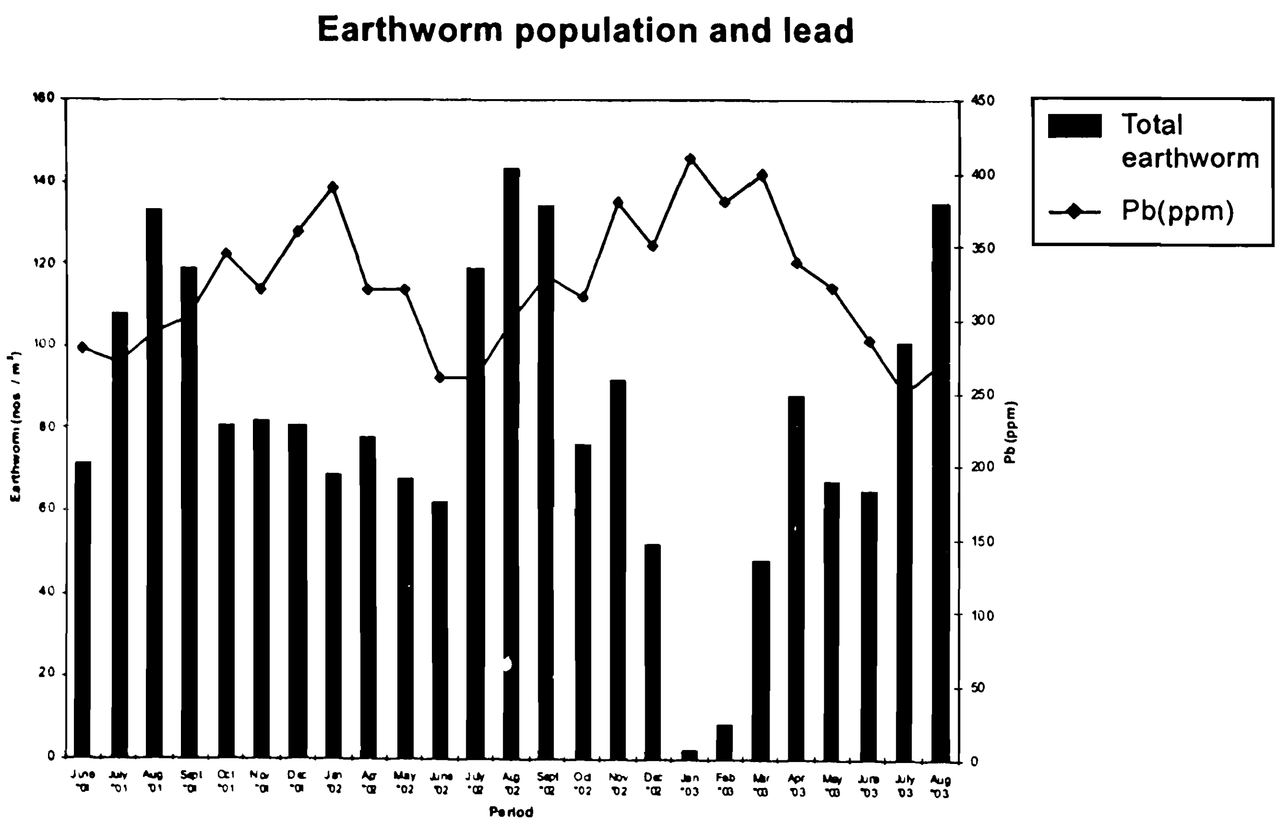


Fig. 12 : Showing monthly fluctuations of earthworm population and Lead at Site I (DP)

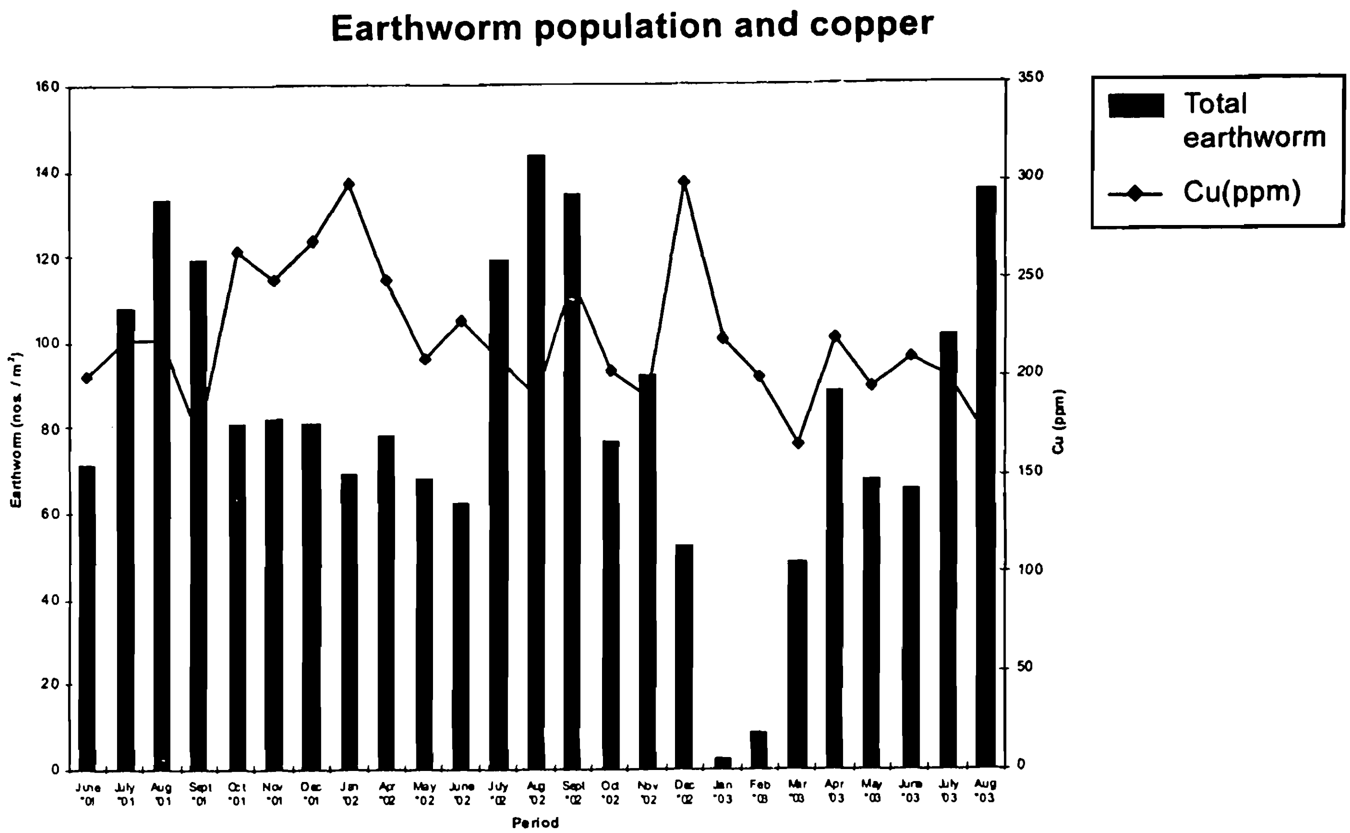


Fig. 13 : Showing monthly fluctuations of earthworm population and Copper at Site I (DP)

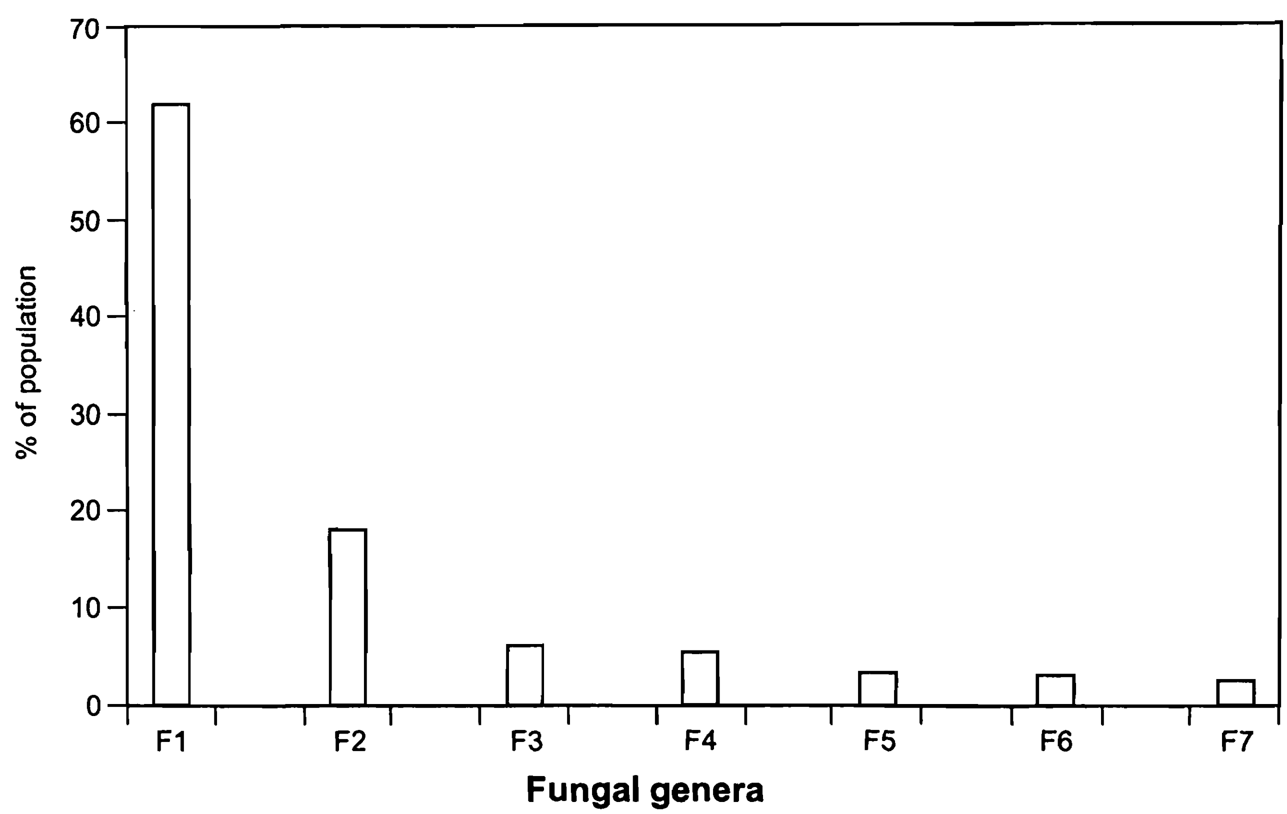


Fig. 14 : Showing composition of fungal community at Site I (DP)

Explanation : *F1 = Penicillium, F2 = Aspergillus, F3 = Fusarium, F4 = Trichoderma, F5 = Rhizopus, F6 = Cephalosporium, F7 = Mucor*

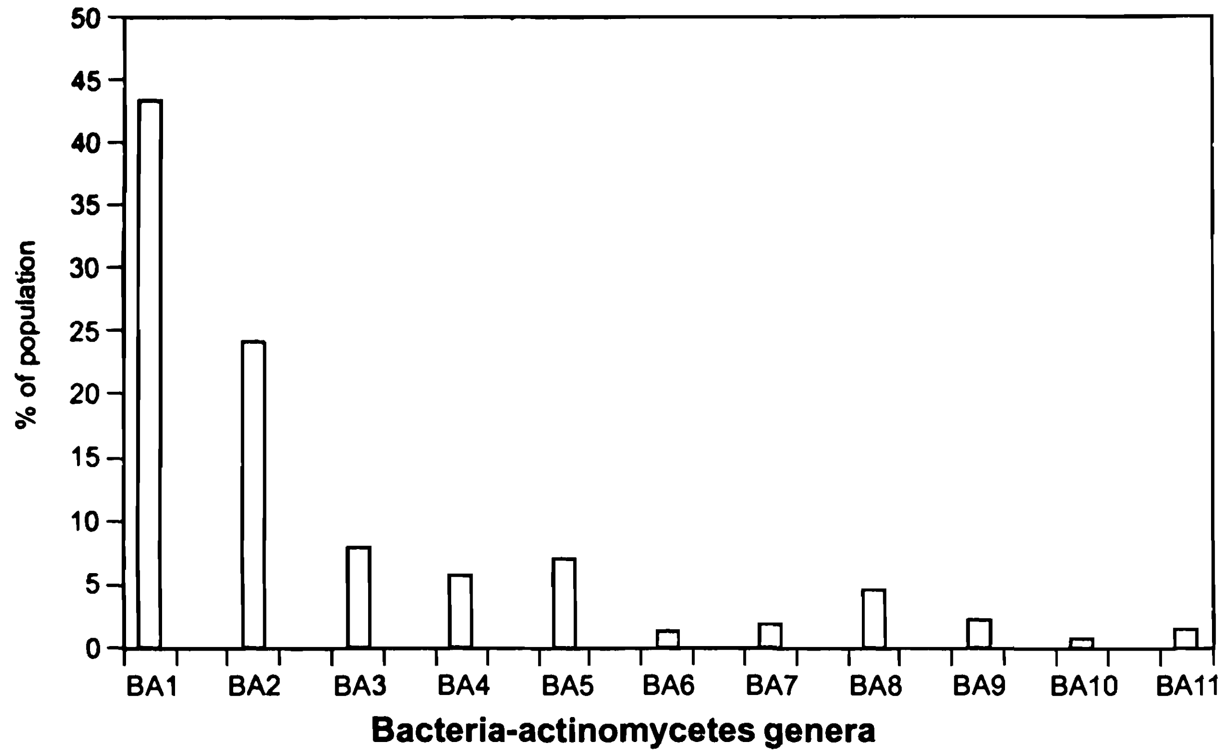


Fig. 15 : Showing composition of bacteria-actinomycetes community at Site I (DP)

Explanation : *BA1 = Bacillus, BA2 = Streptomyces, BA3 = Micrococcus I, BA4 = Micrococcus II, BA5 = Arthrobacter, BA6 = Pseudomonas, BA7 = Promicromonospora, BA8 = Cytophaga, BA9 = E. coli, BA10 = Flavobacterium, BA11 = Enterobacter*

Fluctuations of earthworm, fungi and bacteria-actinomycetes population

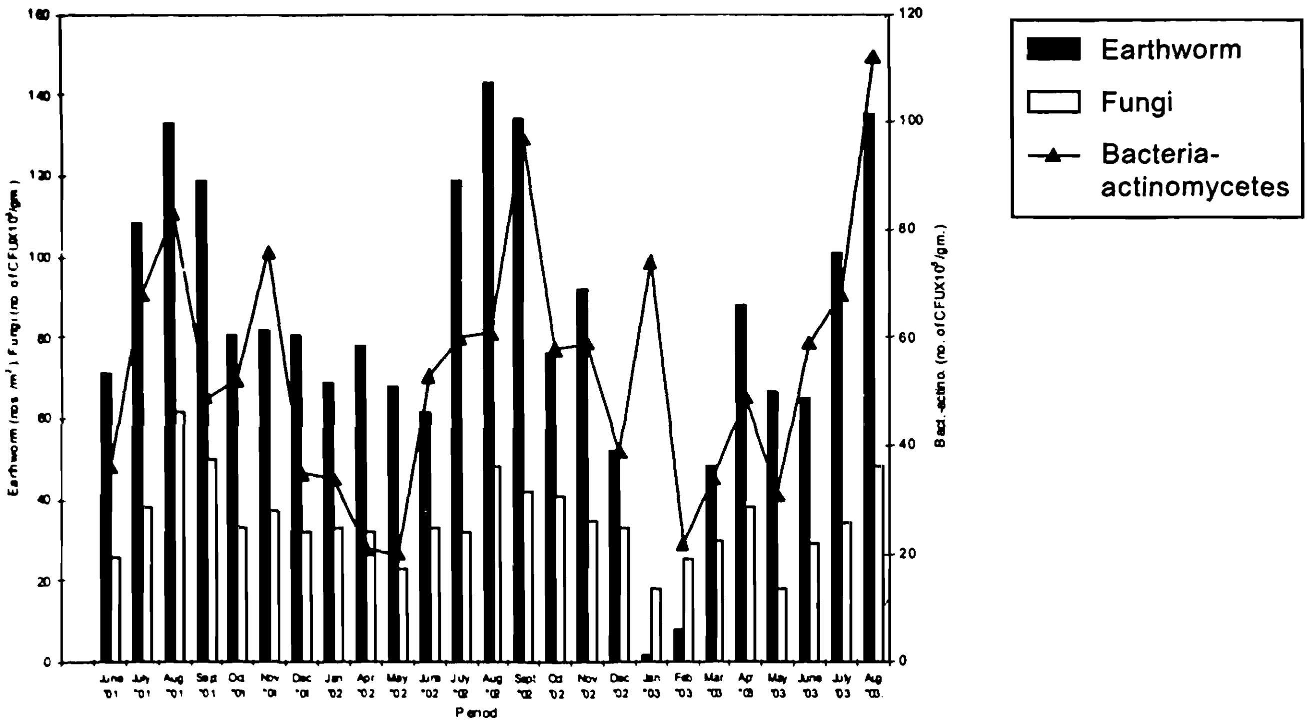


Fig. 16 : Showing monthly fluctuations of Earthworm, Fungi and Bacteria-actinomycetes population at Site I(DP)

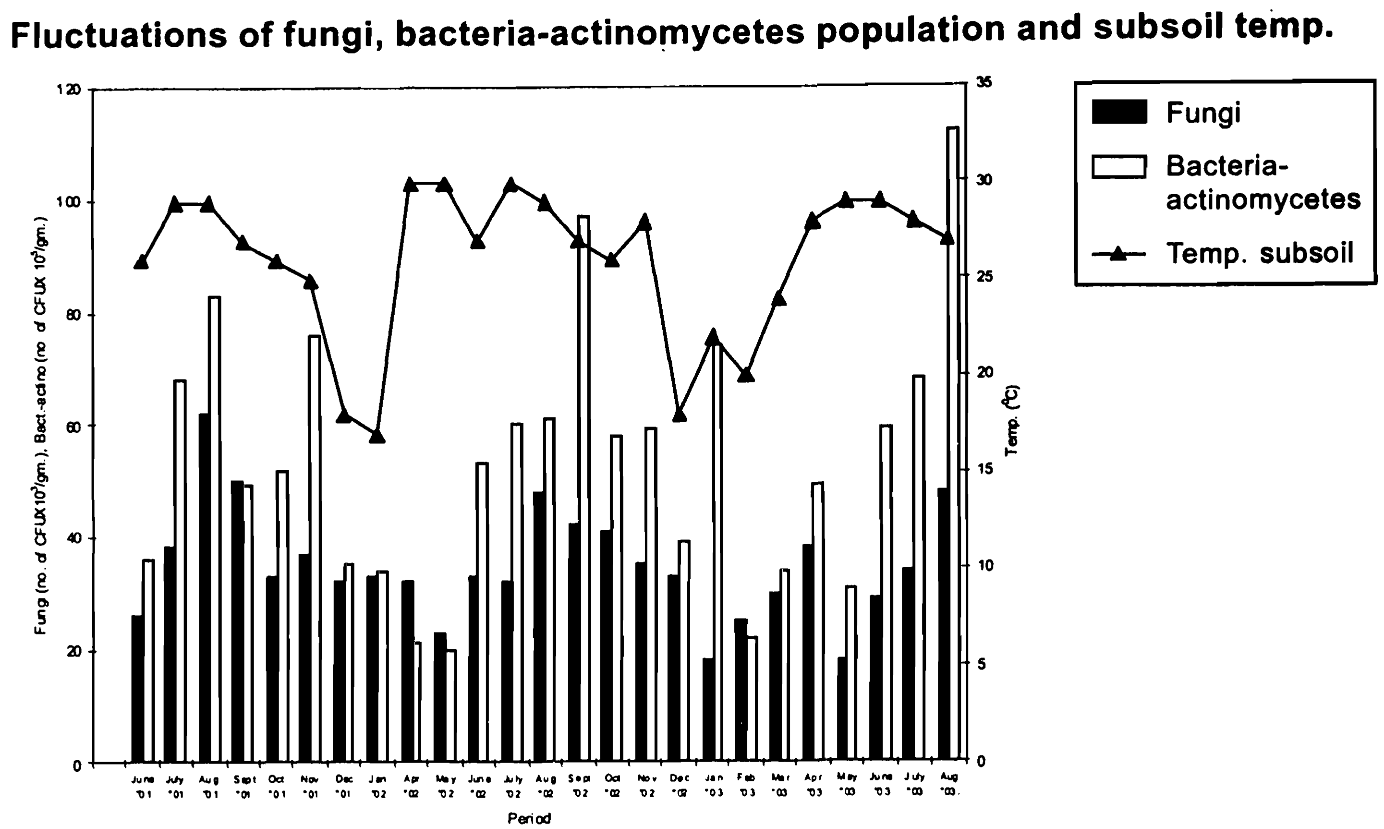


Fig. 17 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and subsoil temperature at Site I (DP)

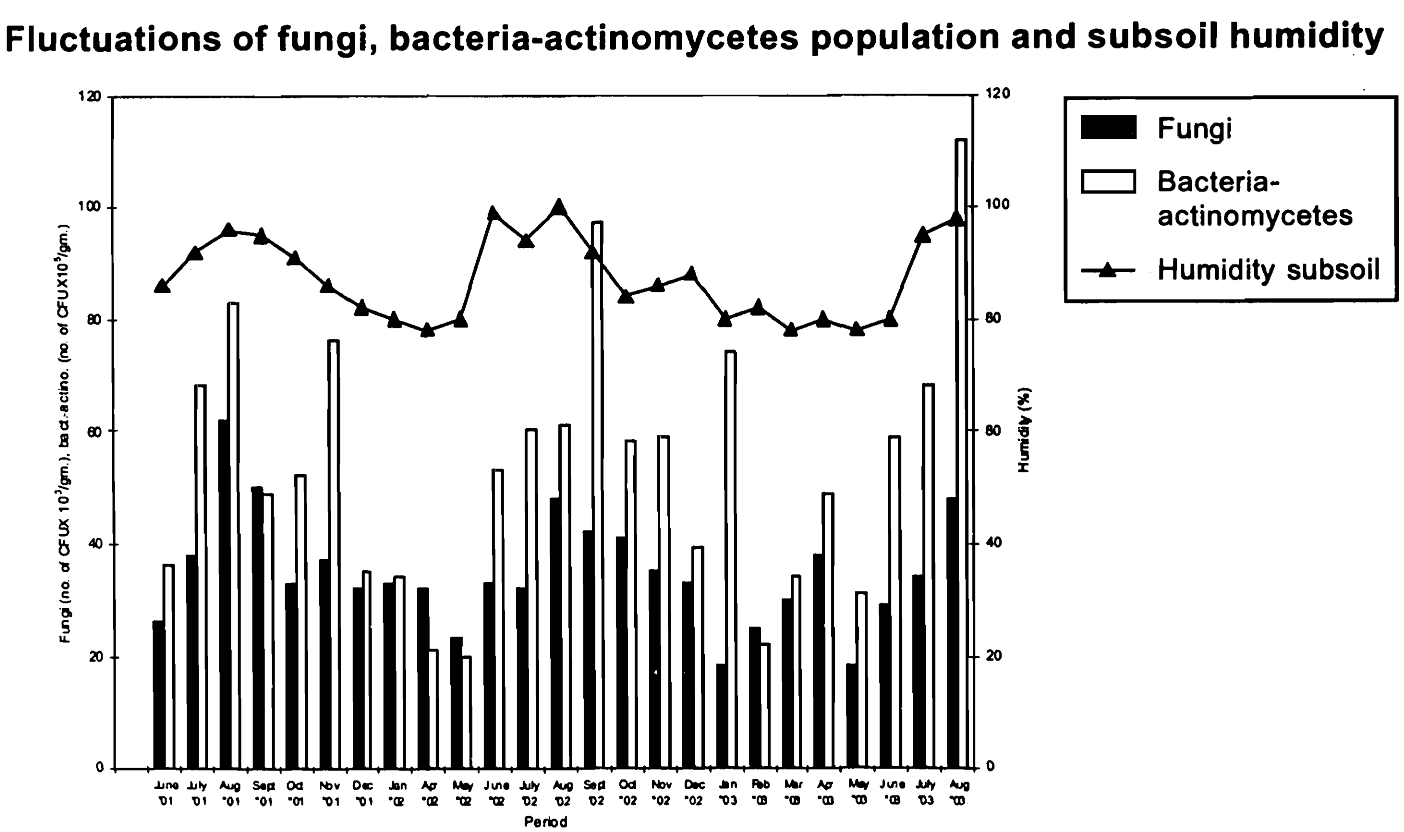


Fig. 18 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and subsoil relative humidity at Site I (DP)

Fluctuations of fungi, bacteria-actinomycetes population and pH

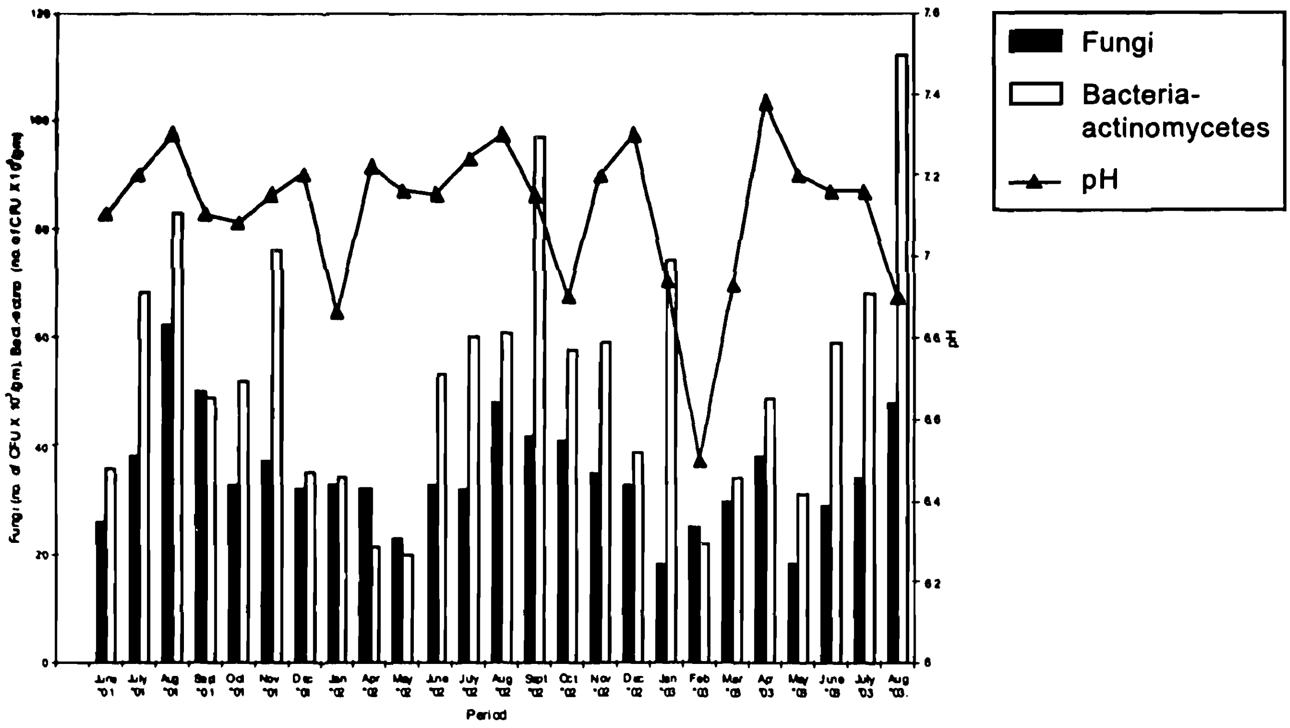


Fig. 19 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and pH at Site I (DP)

Fluctuations of fungi, bacteria-actinomycetes population and E.C.

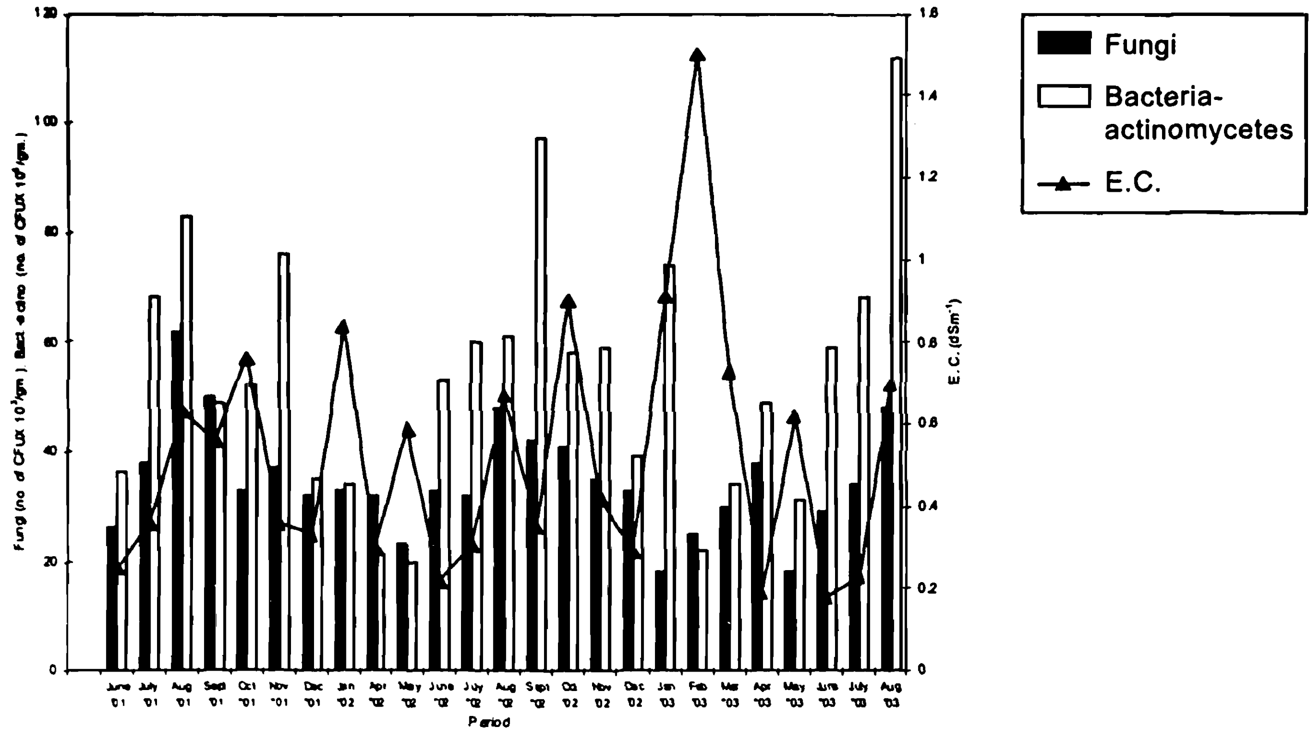


Fig. 20 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and electrical conductivity at Site I (DP)

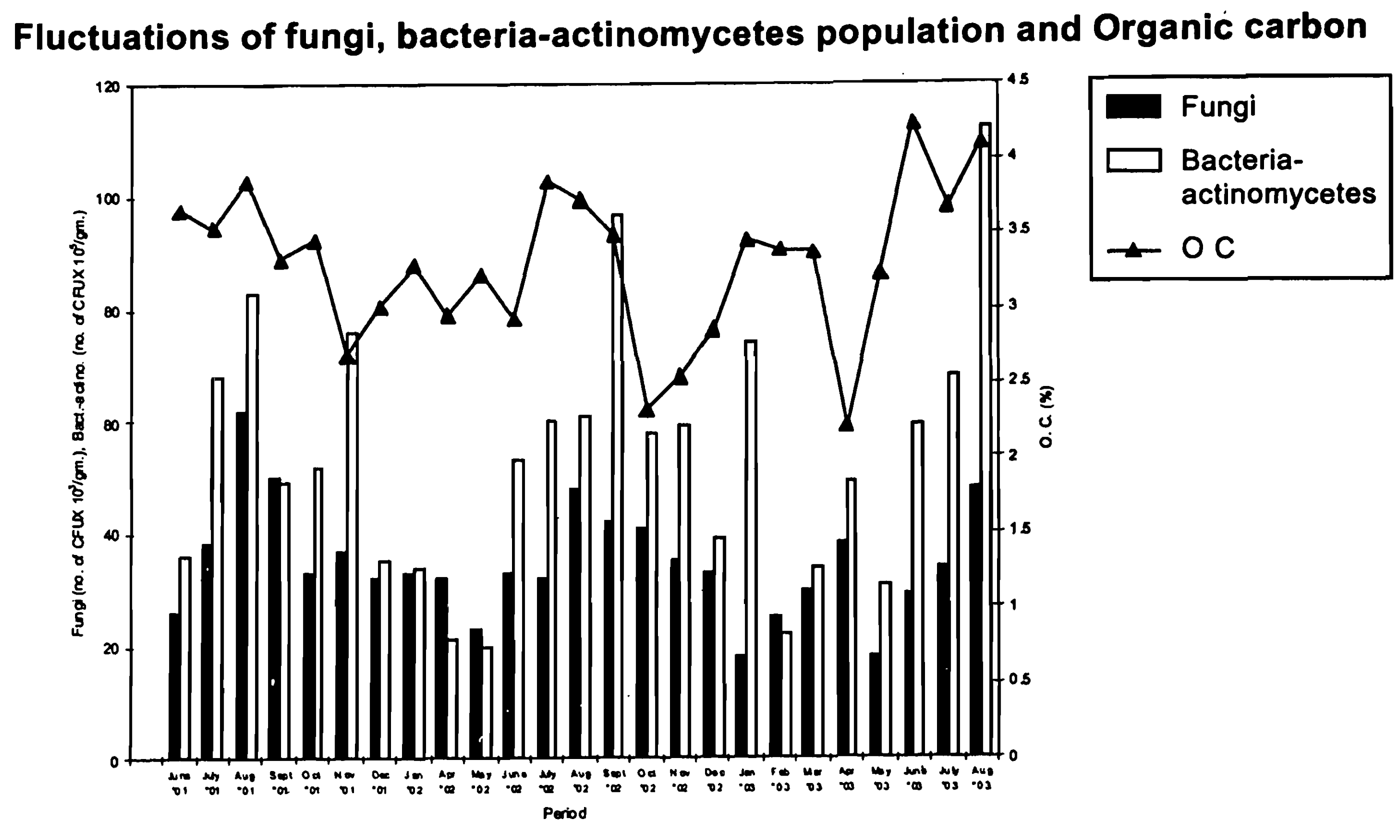


Fig. 21 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and organic Carbon at Site I (DP)

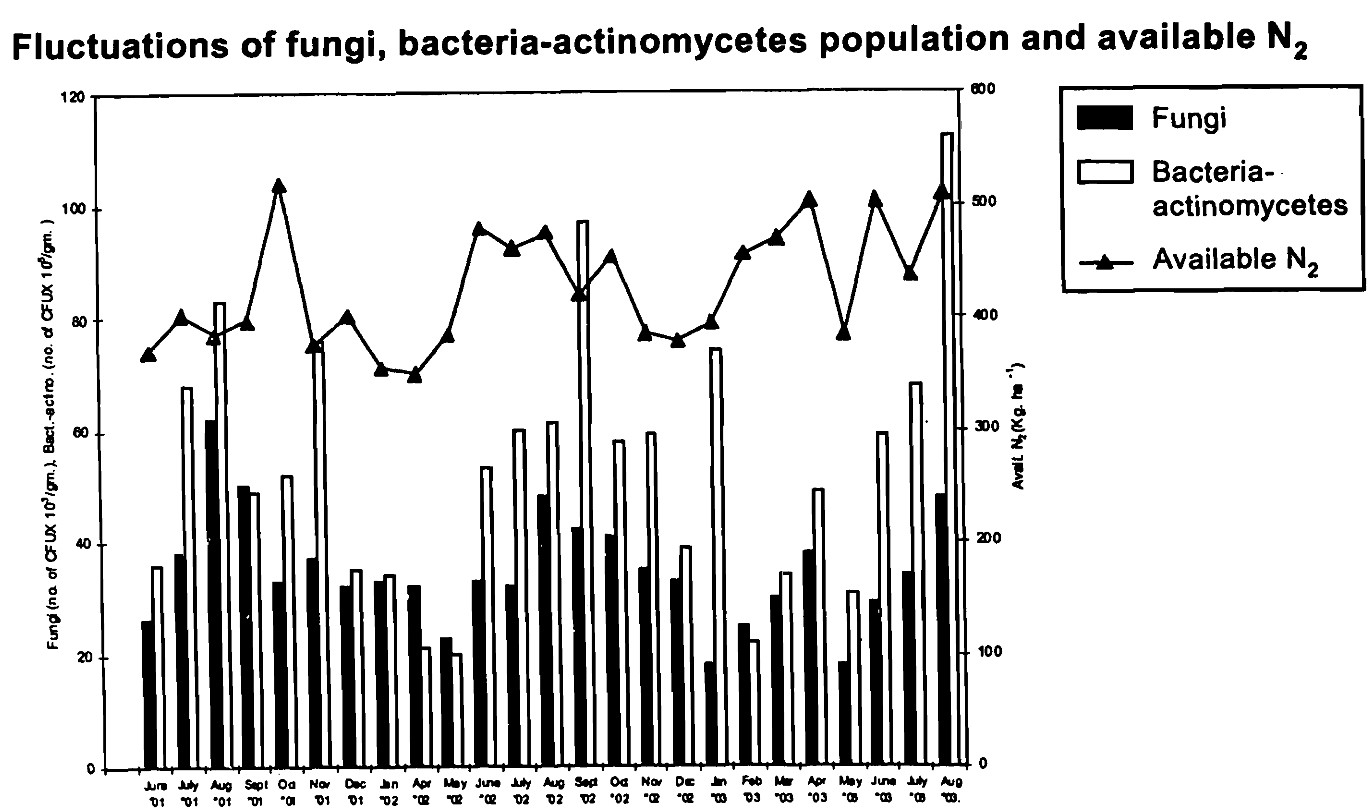


Fig. 22 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and available Nitrogen at Site I (DP)

Fluctuations of fungi, bacteria-actinomycetes and available P_2O_5

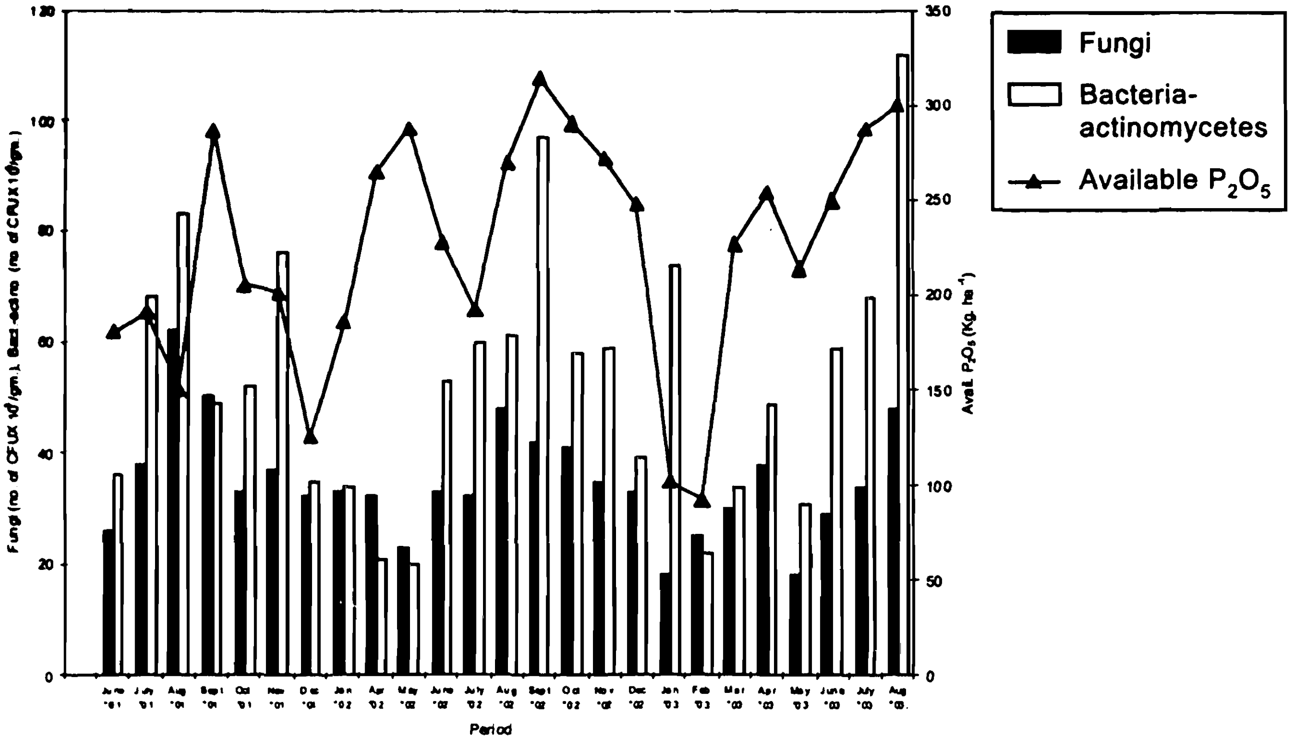


Fig. 23 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and available P_2O_5 at Site I (DP)

Fluctuations of fungi, bacteria-actinomycetes population and avail. K_2O

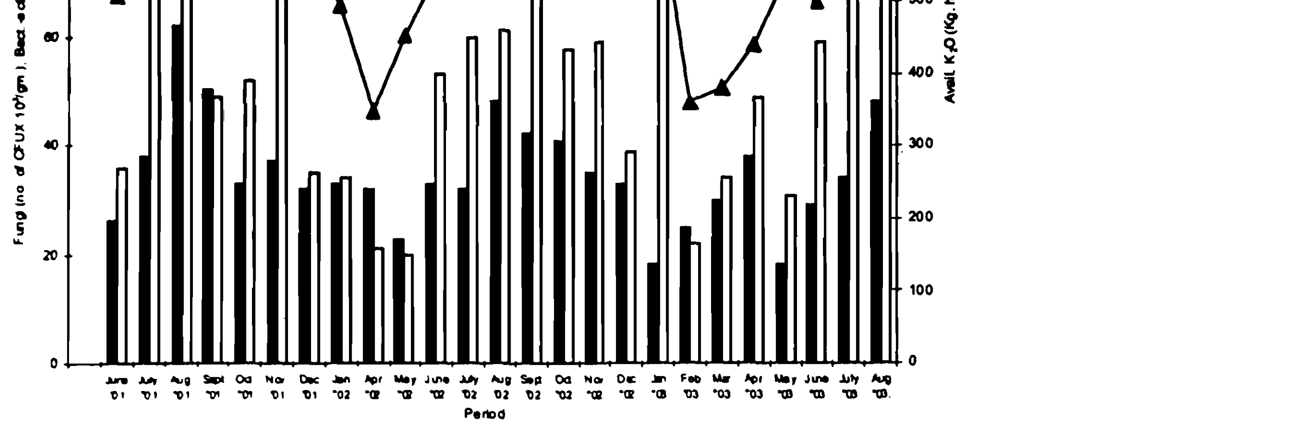


Fig. 24 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and available K_2O at Site I (DP)

Fluctuations of fungi, bacteria-actinomycetes population and cadmium

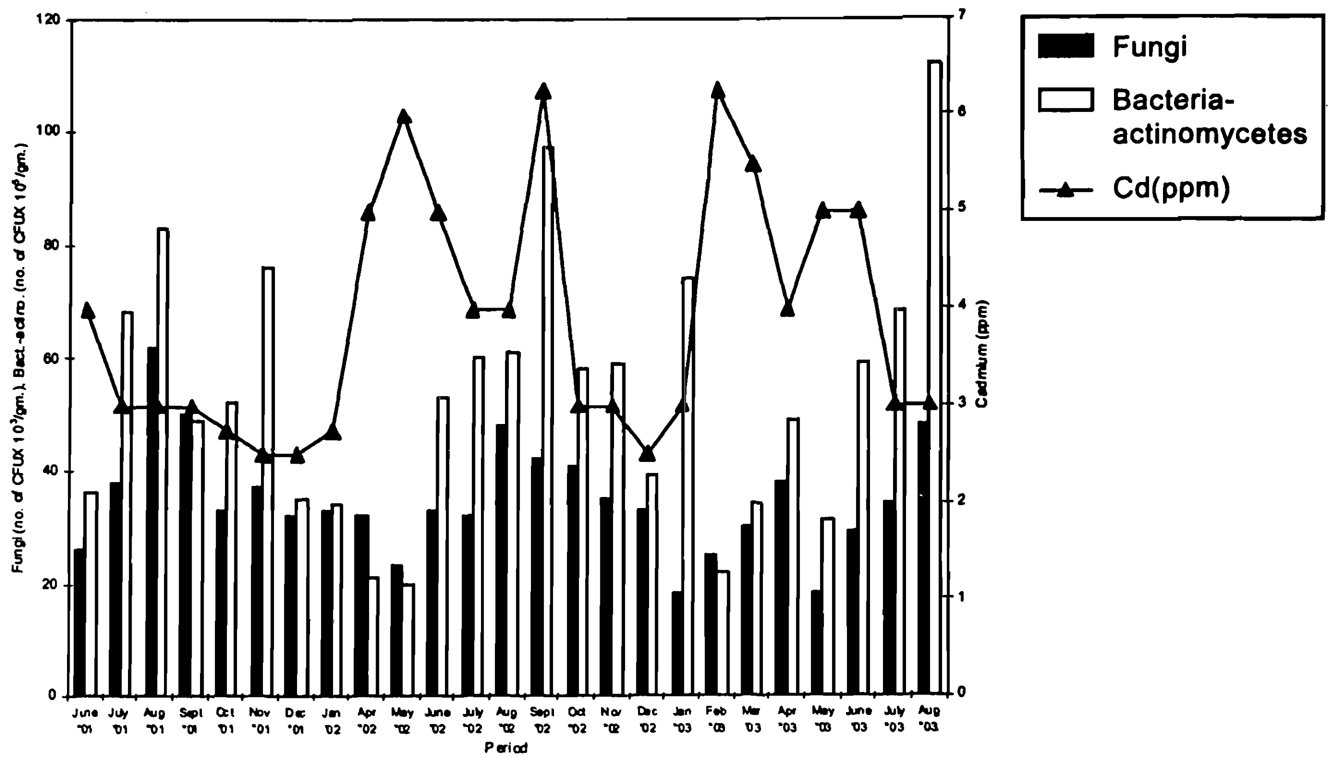


Fig. 25 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Cadmium at Site I (DP)

Fluctuations of fungi, bacteria-actinomycetes population and zinc

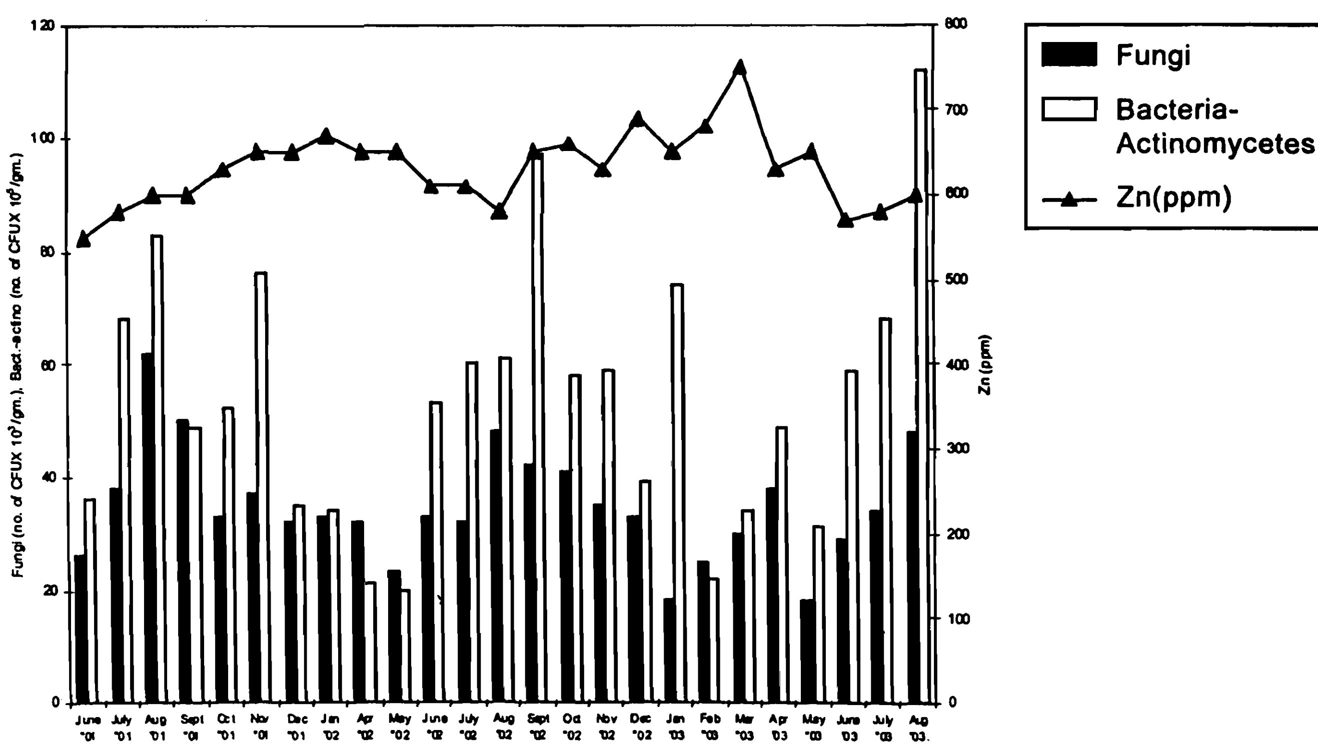


Fig. 26 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Zinc at Site I (DP)

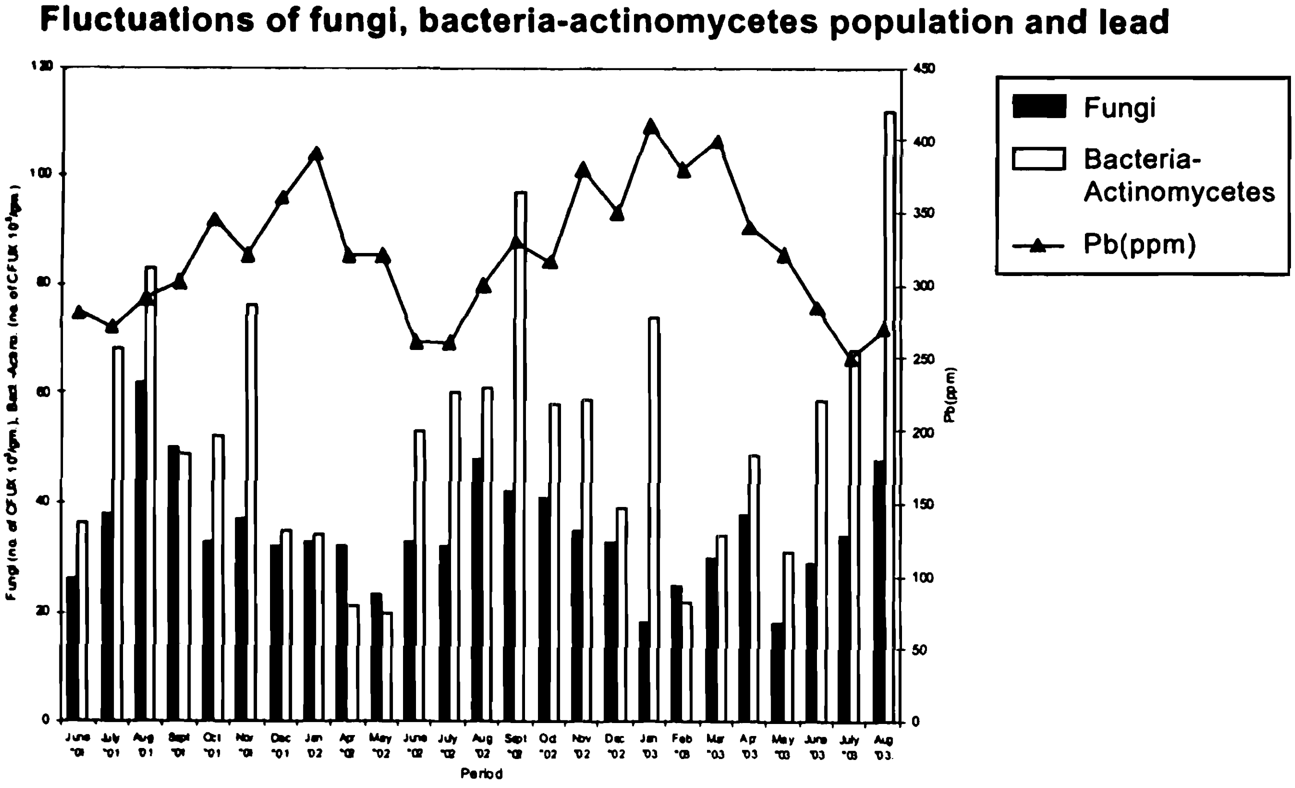


Fig. 27 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Lead at Site I (DP)

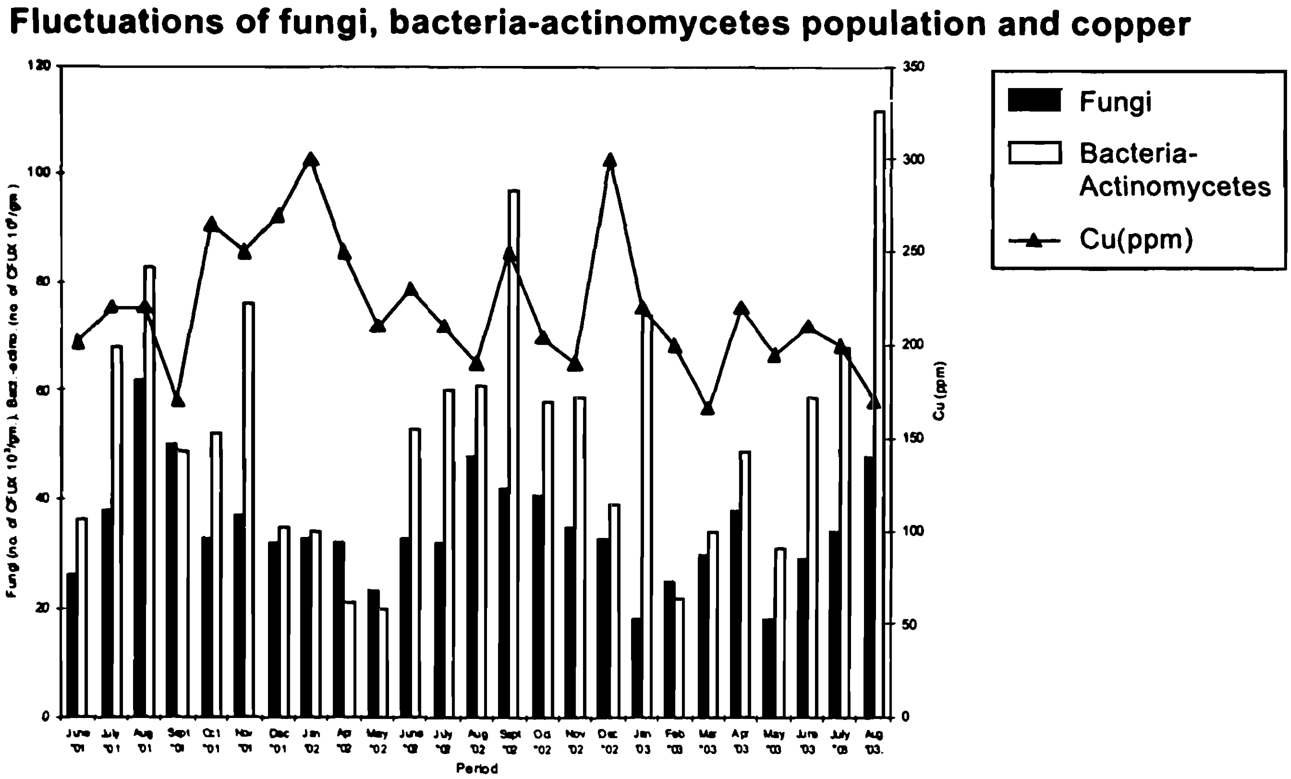


Fig. 28 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Copper at Site I (DP)

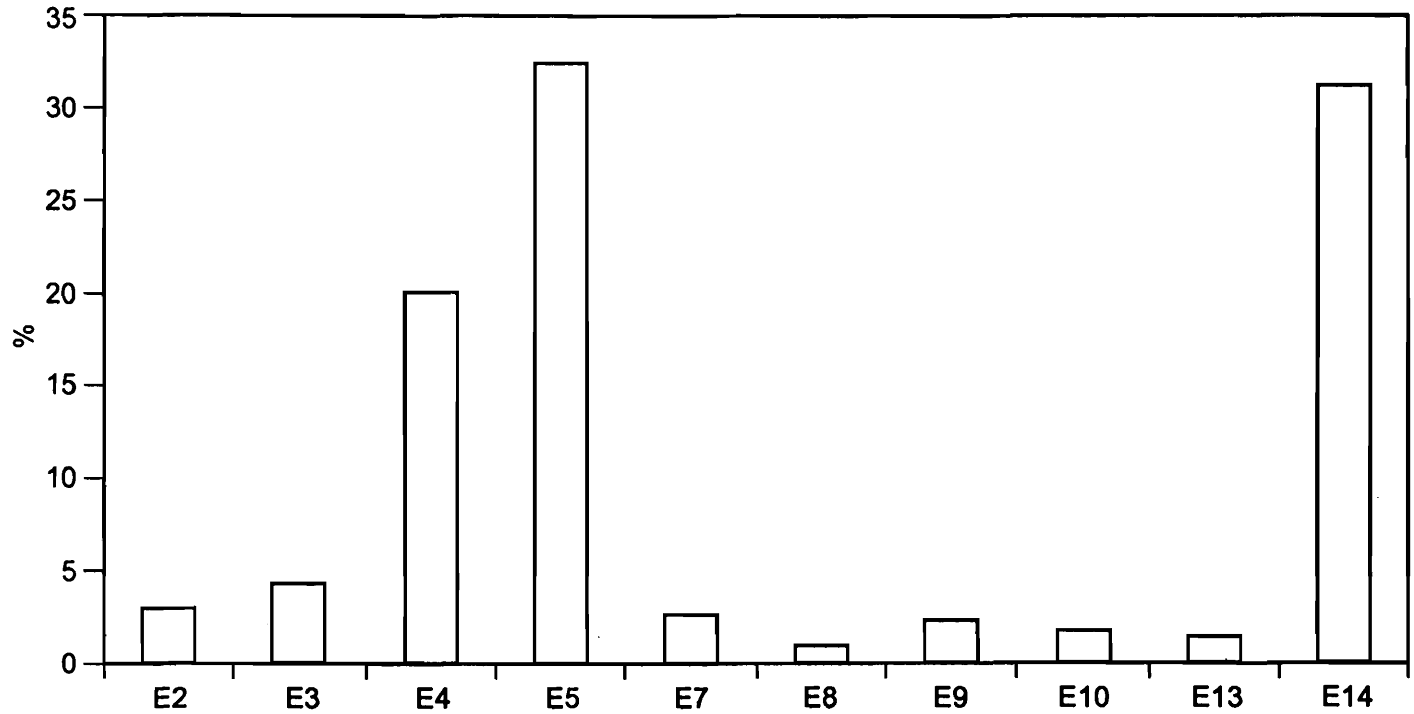


Fig. 29 : Showing composition of earthworm community at Site II (MD)

Explanations : *E2 = Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E7 = Drawida nepalensis; E8 = Perionyx simlaensis; E9 = Polypheretima elongata; E10 = Metaphire houlleti; E13 = Octochaetona surensis; E14 = Drawida papillifer papillifer*

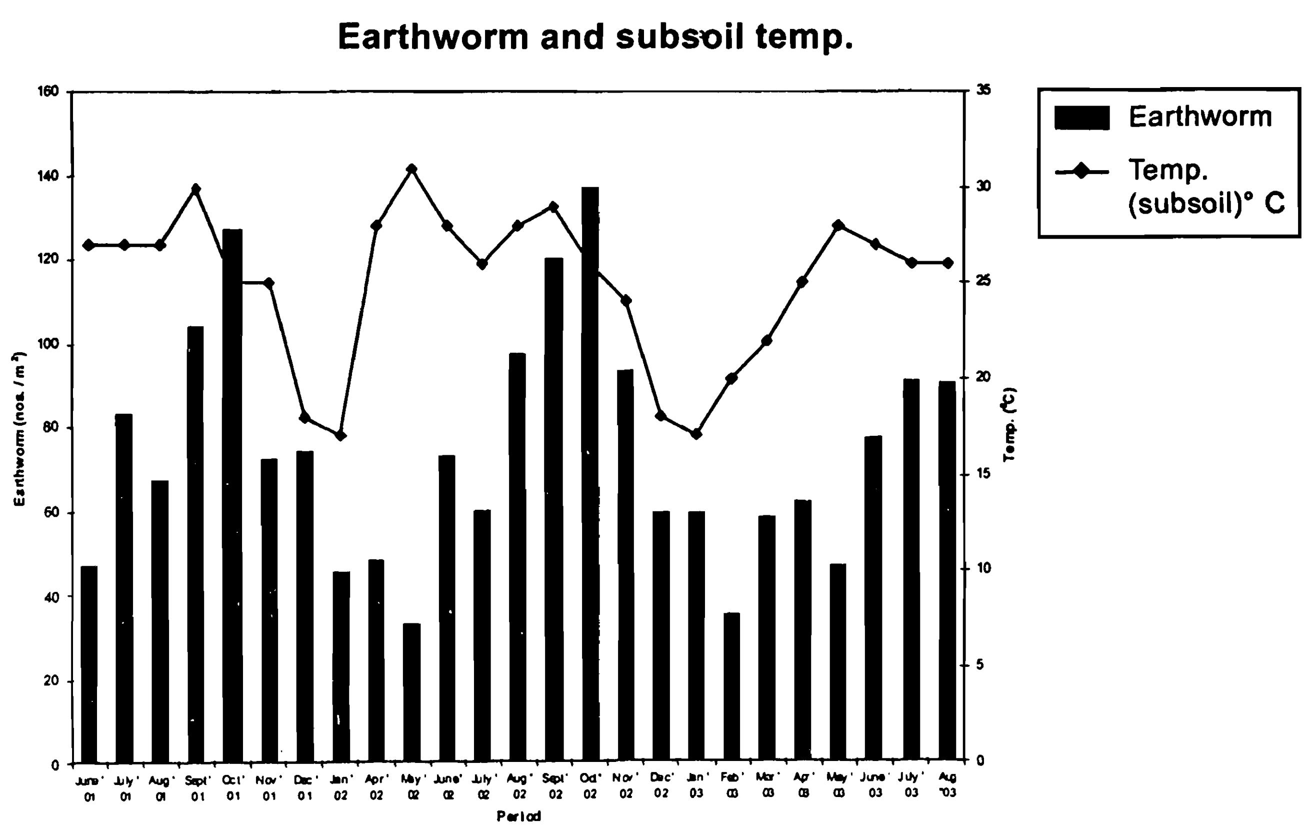


Fig. 30 : Showing monthly fluctuations of earthworm population and subsoil temperature at Site II (MD)

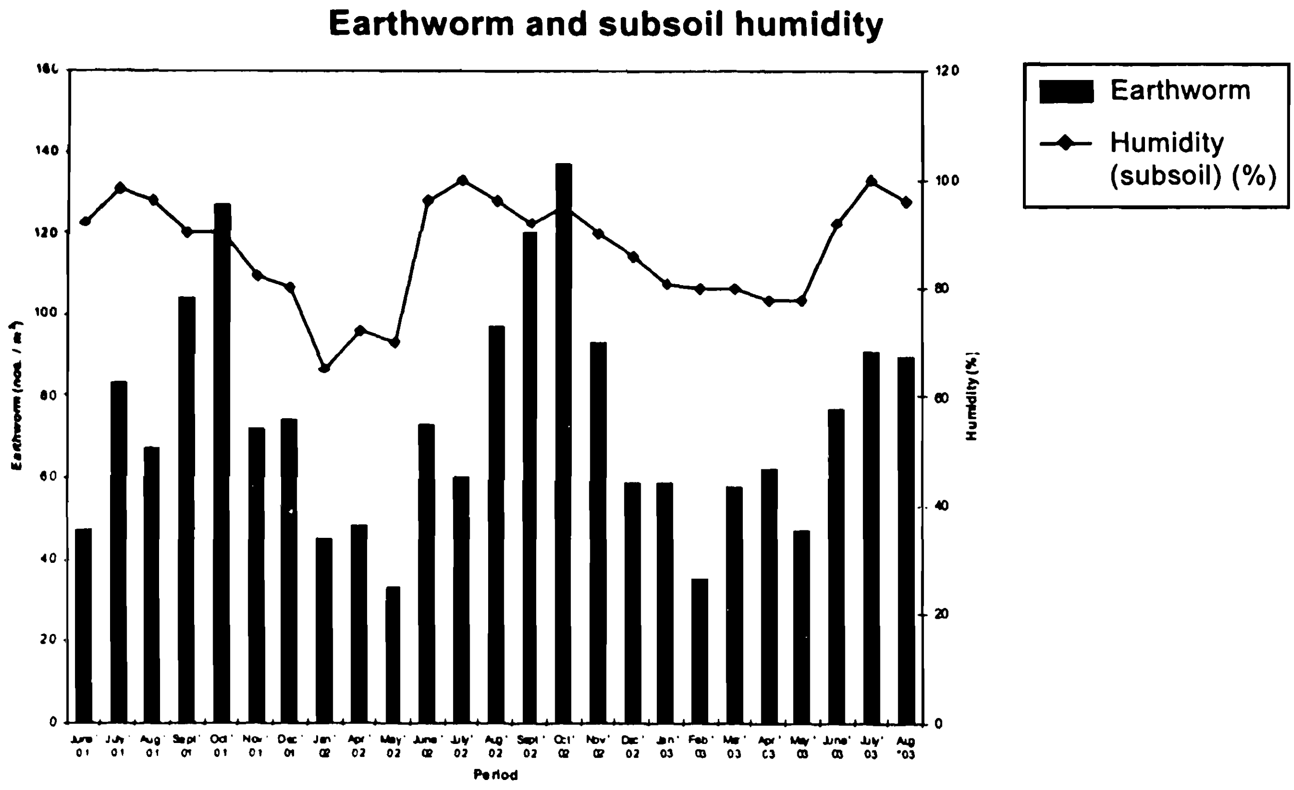


Fig. 31 : Showing monthly fluctuations of earthworm population and subsoil relative humidity at Site II (MD)

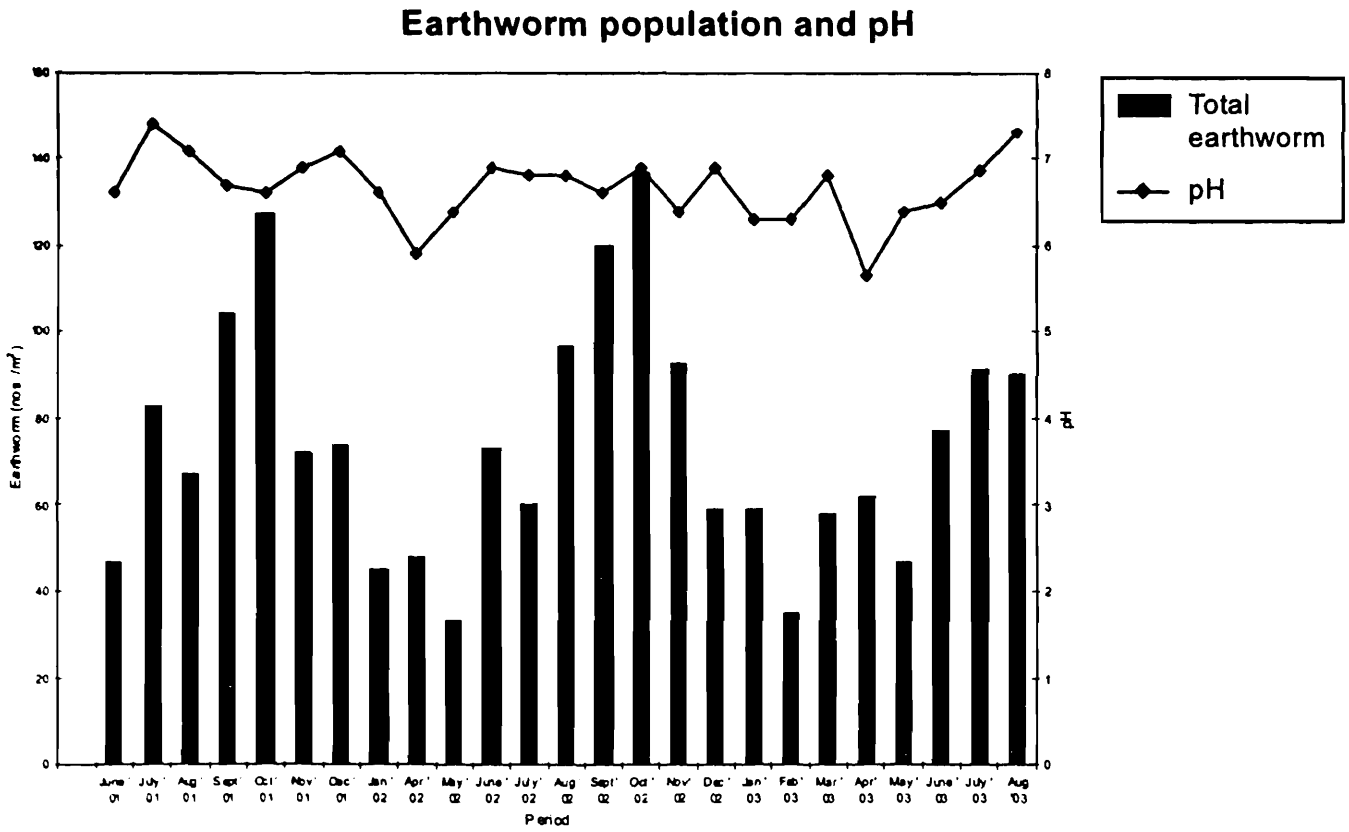


Fig. 32 : Showing monthly fluctuations of earthworm population and pH at Site II (MD)

Earthworm and E.C.

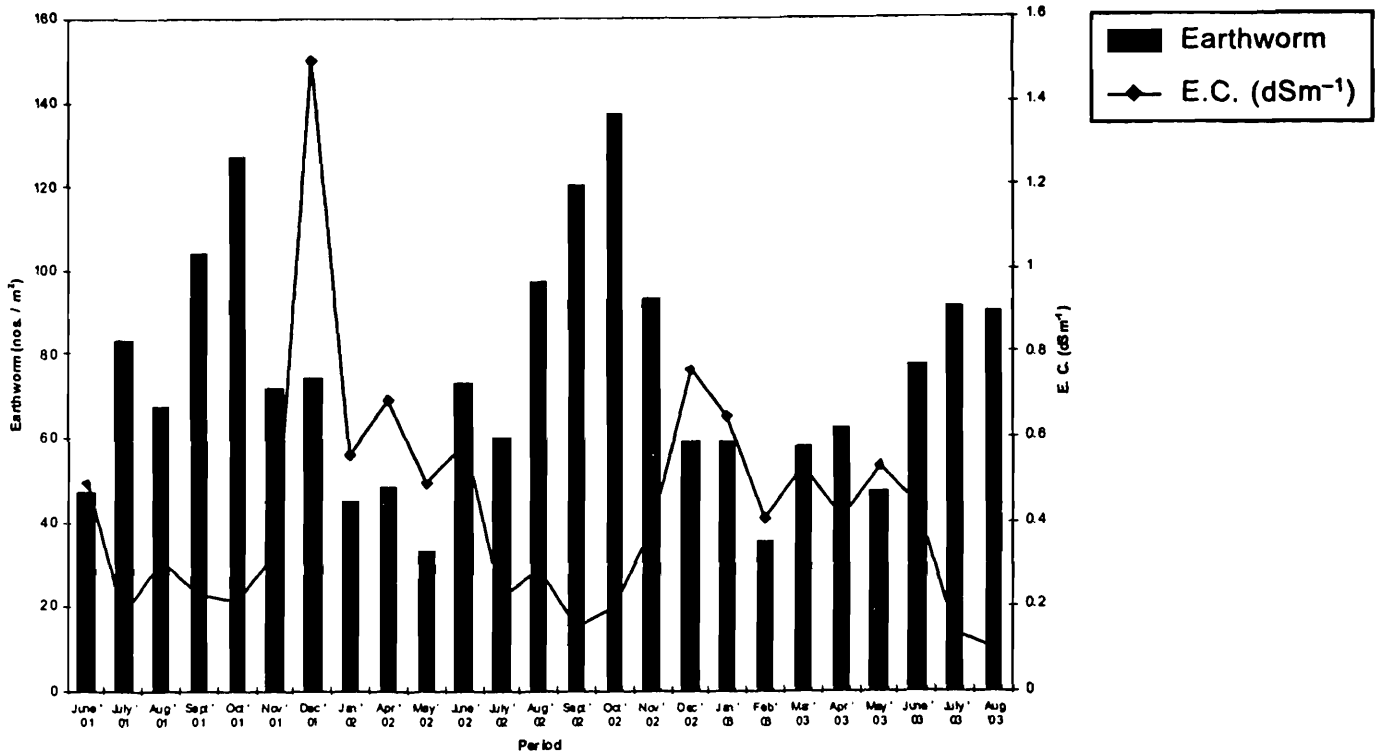


Fig. 33 : Showing monthly fluctuations of earthworm population and electrical conductivity at Site II (MD)

Earthworm and organic carbon

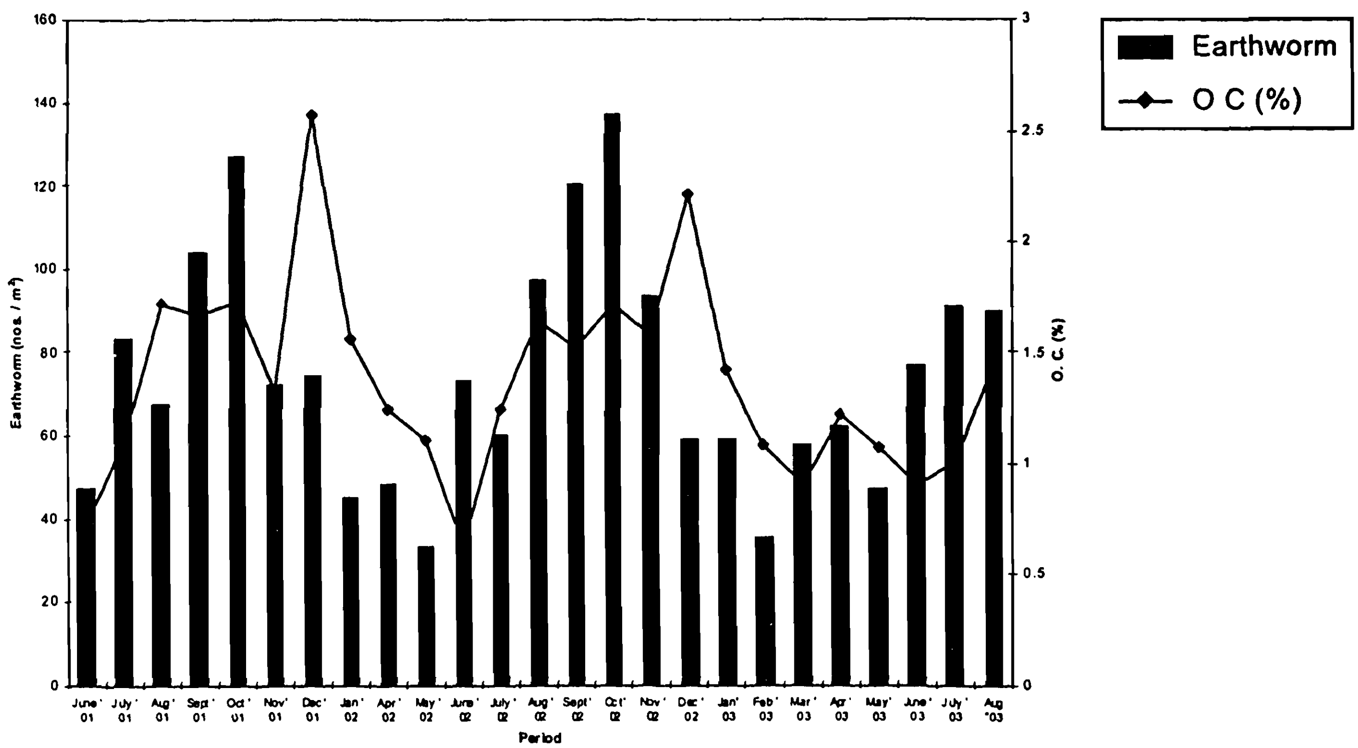


Fig. 34 : Showing monthly fluctuations of earthworm population and organic Carbon at Site II (MD)

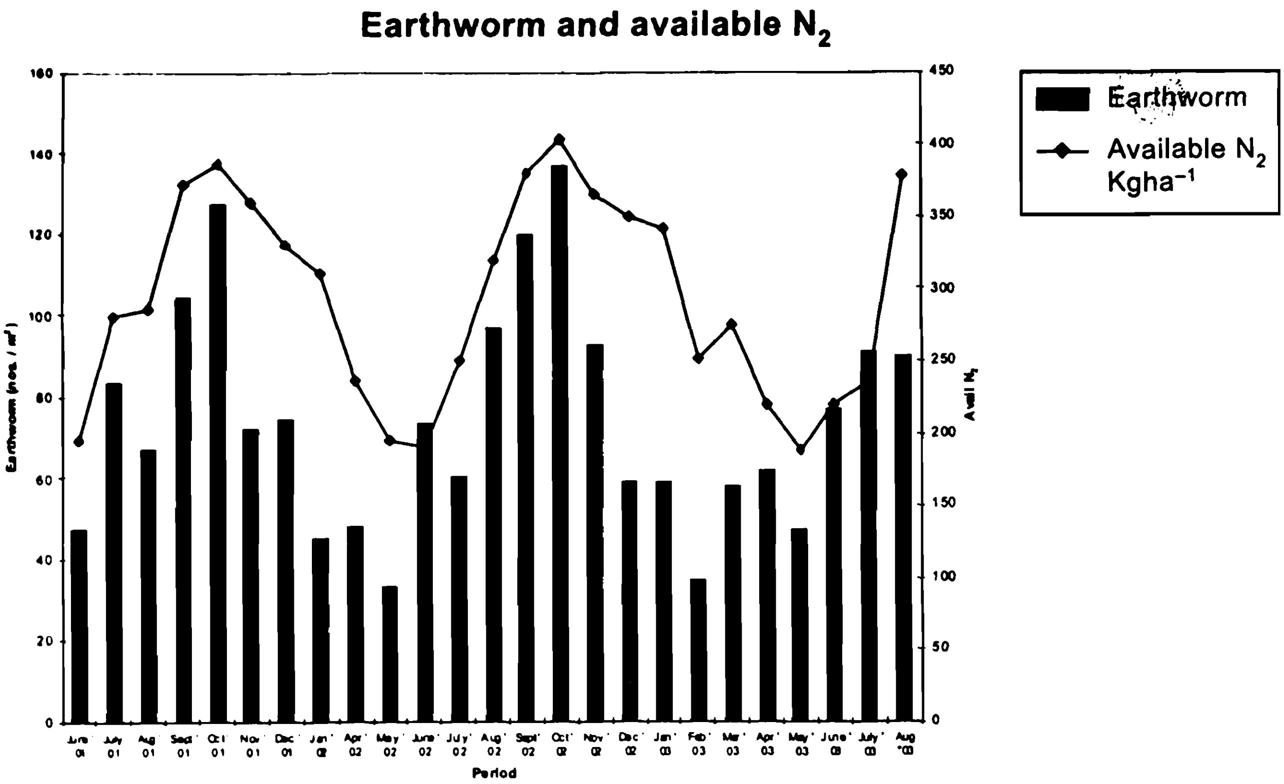


Fig. 35 : Showing monthly fluctuations of earthworm population and available Nitrogen at Site II (MD)

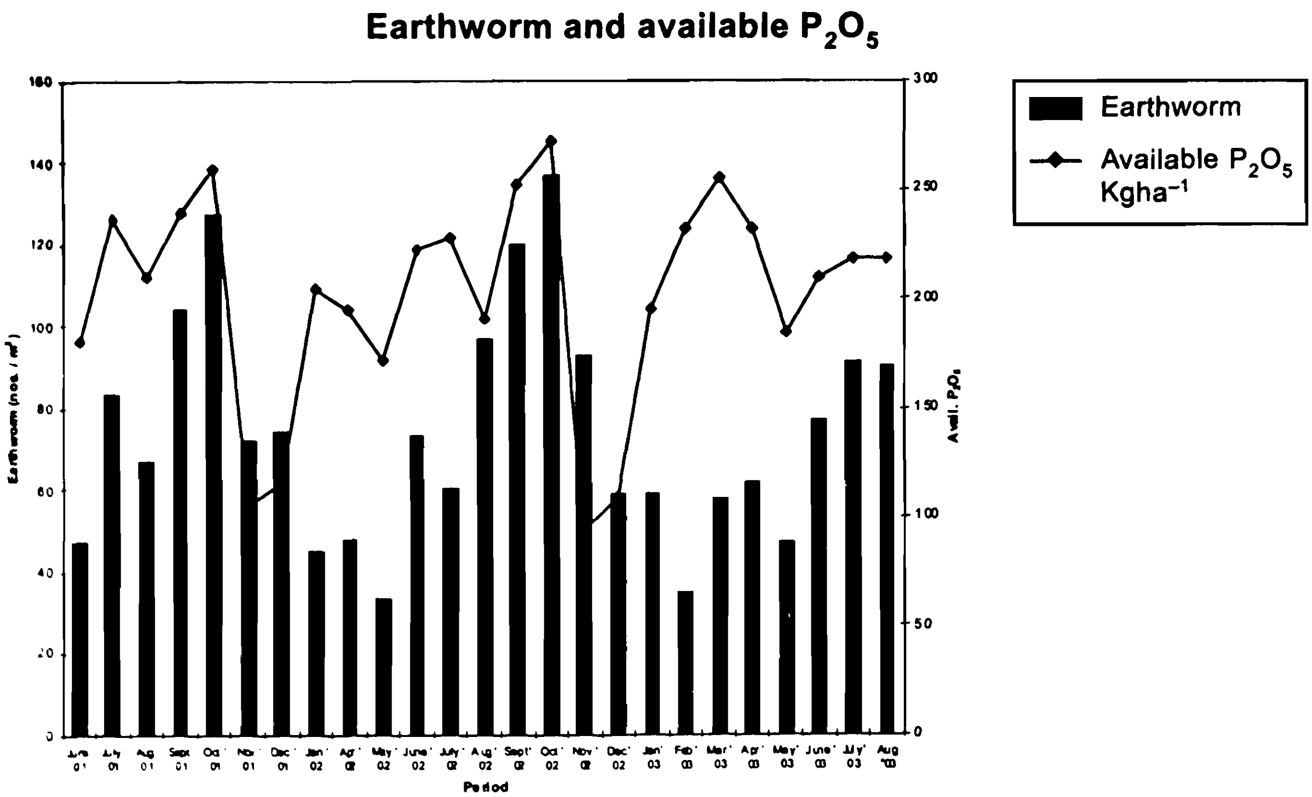


Fig. 36 : Showing monthly fluctuations of earthworm population and available P_2O_5 at Site II (MD)

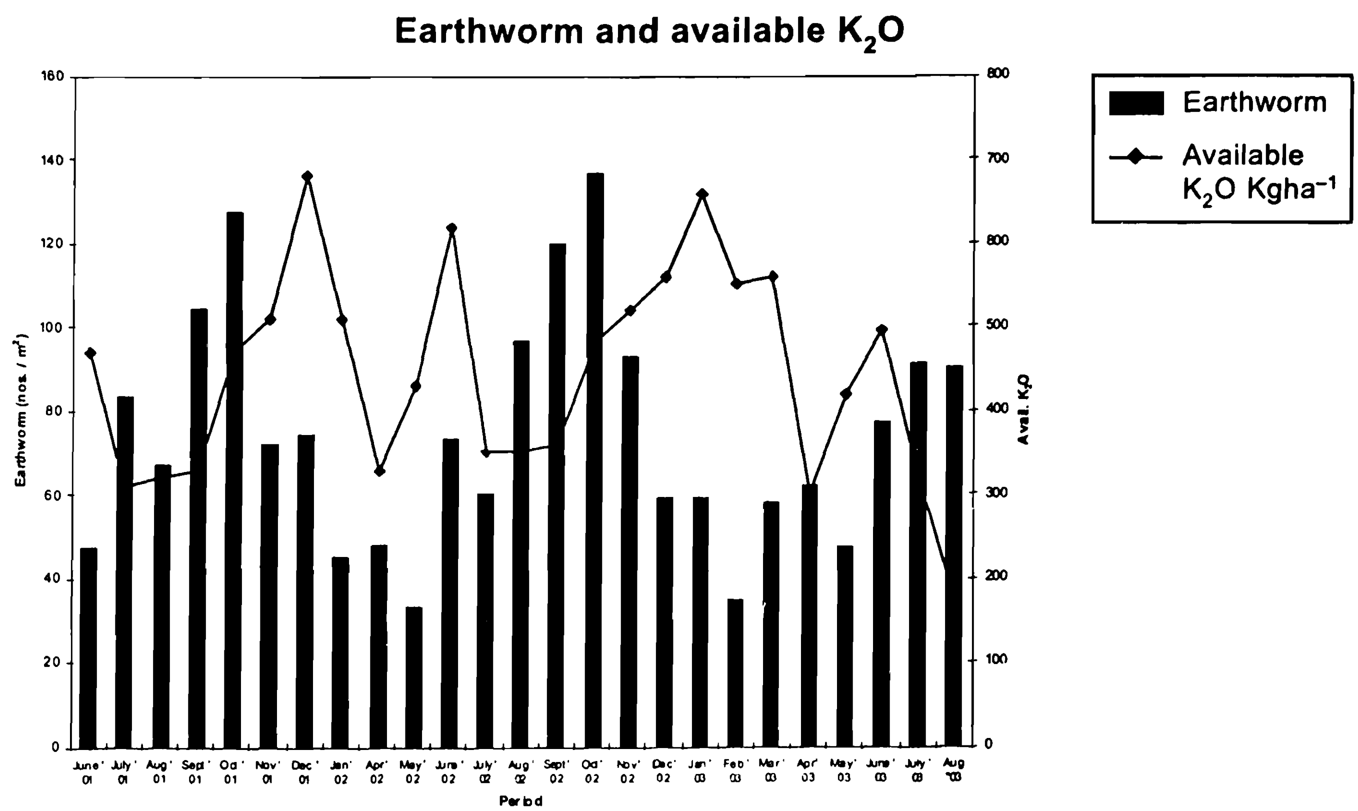


Fig. 37 : Showing monthly fluctuations of earthworm population and available K_2O at Site II (MD)

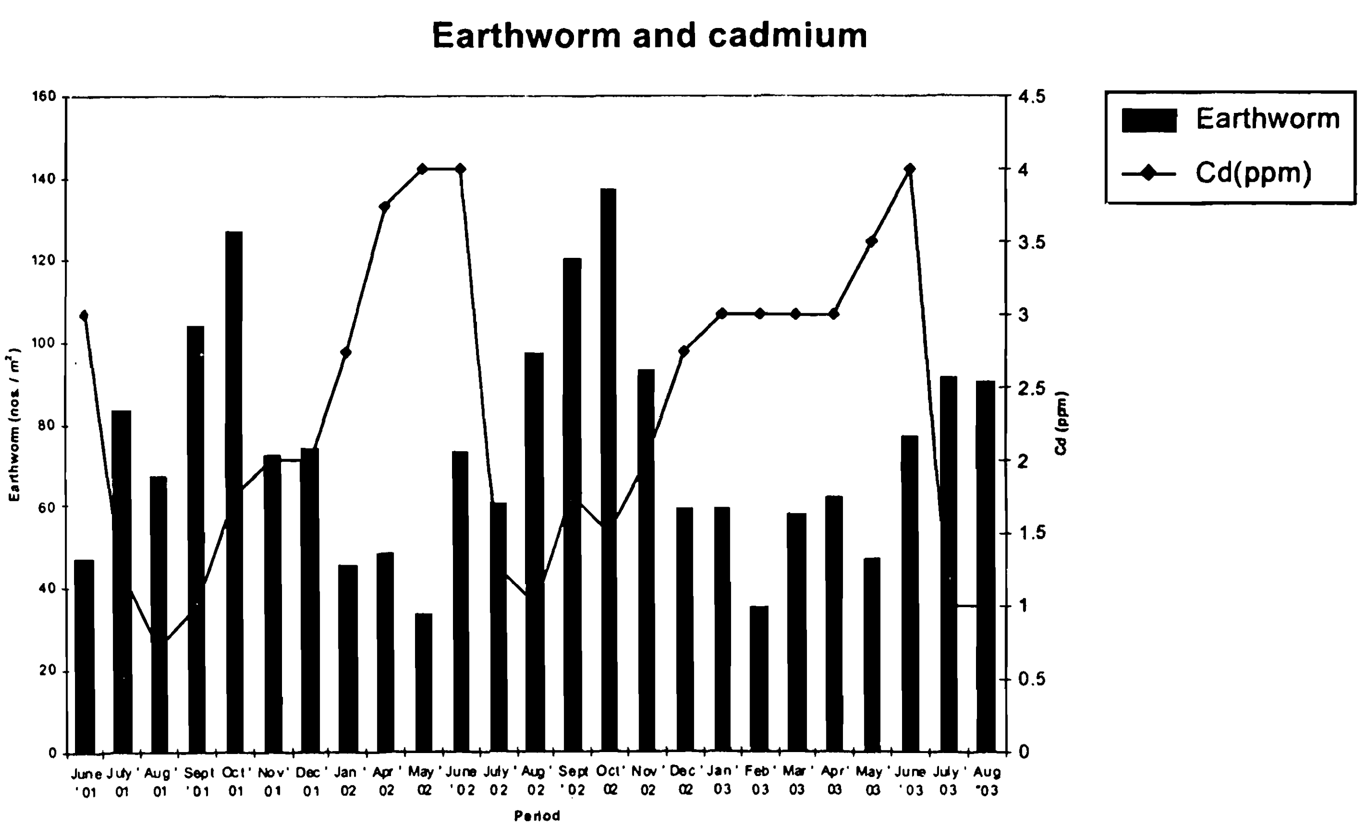


Fig. 38 : Showing monthly fluctuations of earthworm population and Cadmium at Site II (MD)

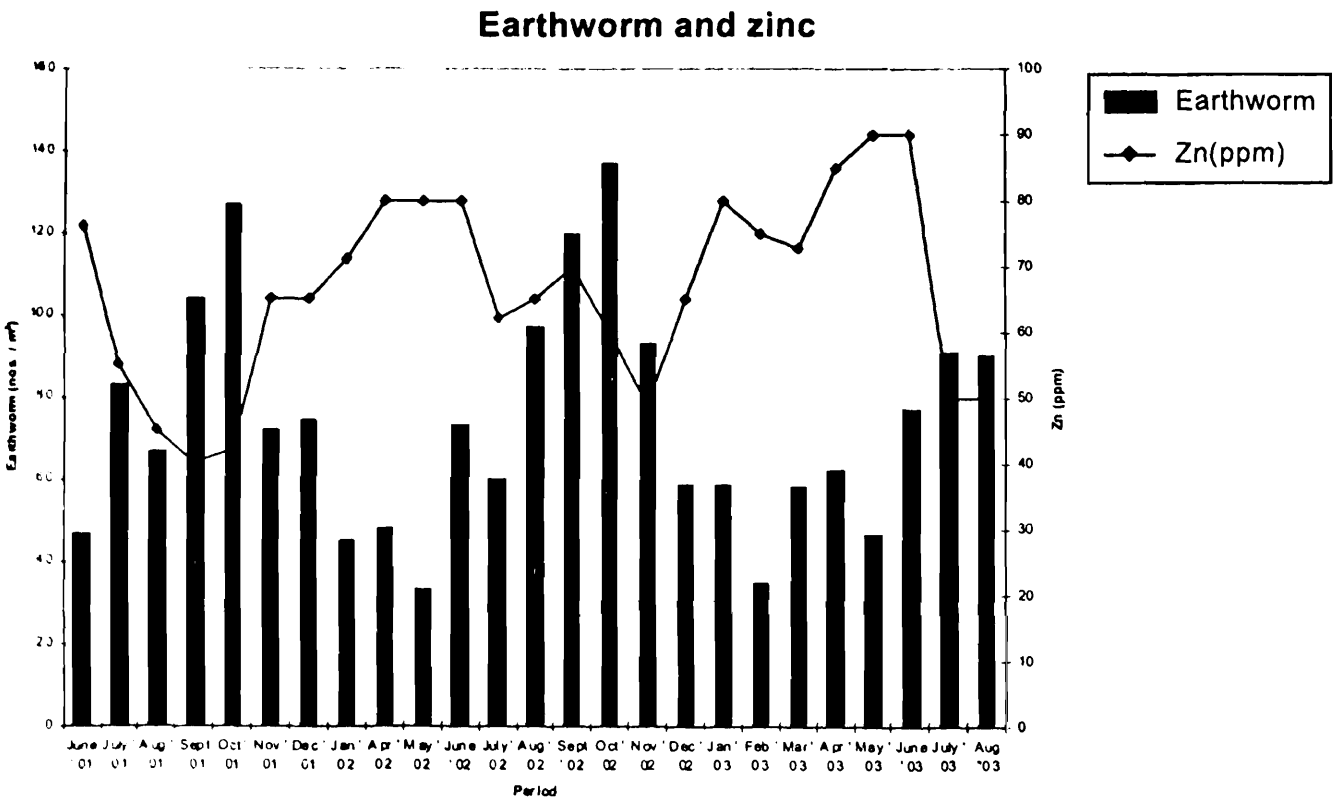


Fig. 39 : Showing monthly fluctuations of earthworm population and Zinc at Site II (MD)

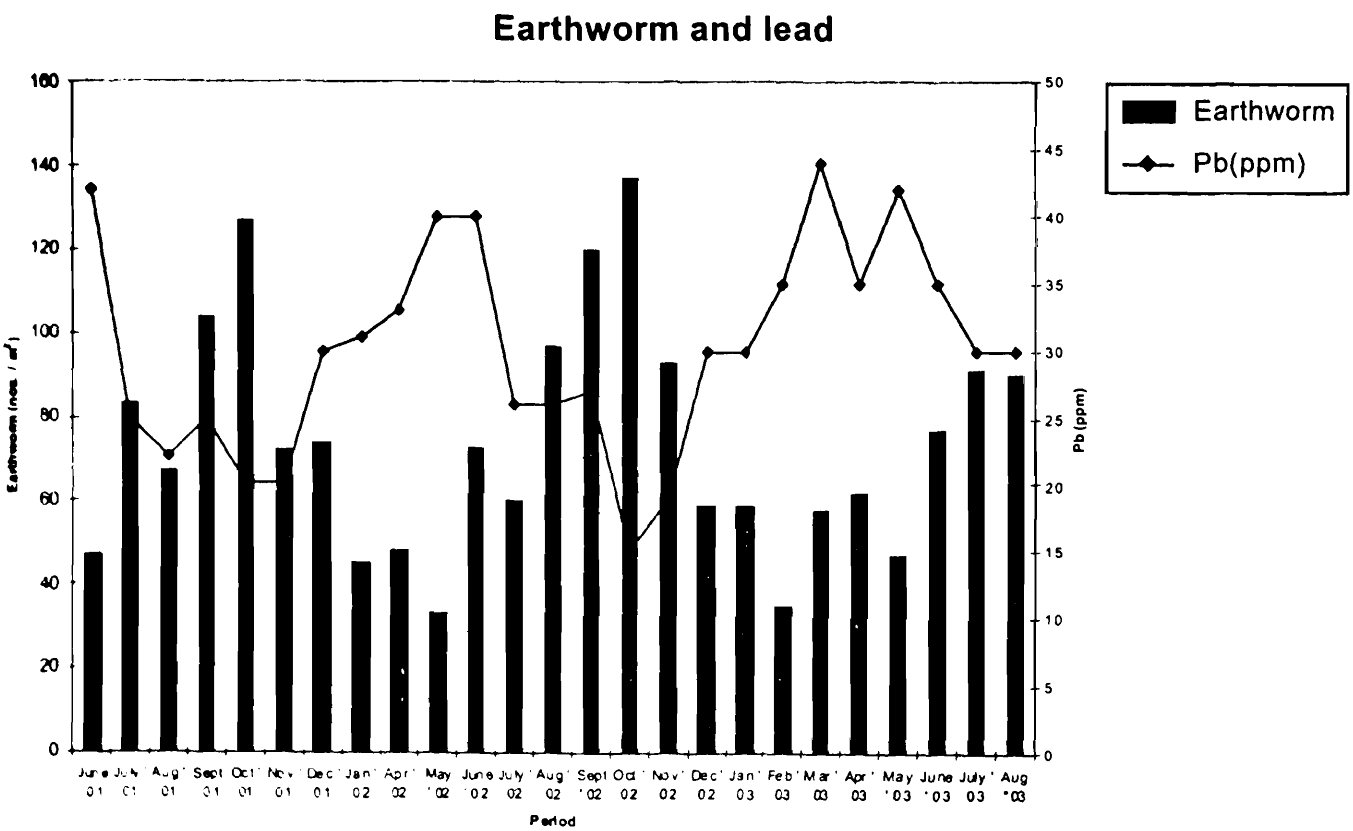


Fig. 40 : Showing monthly fluctuations of earthworm population and Lead at Site II (MD)

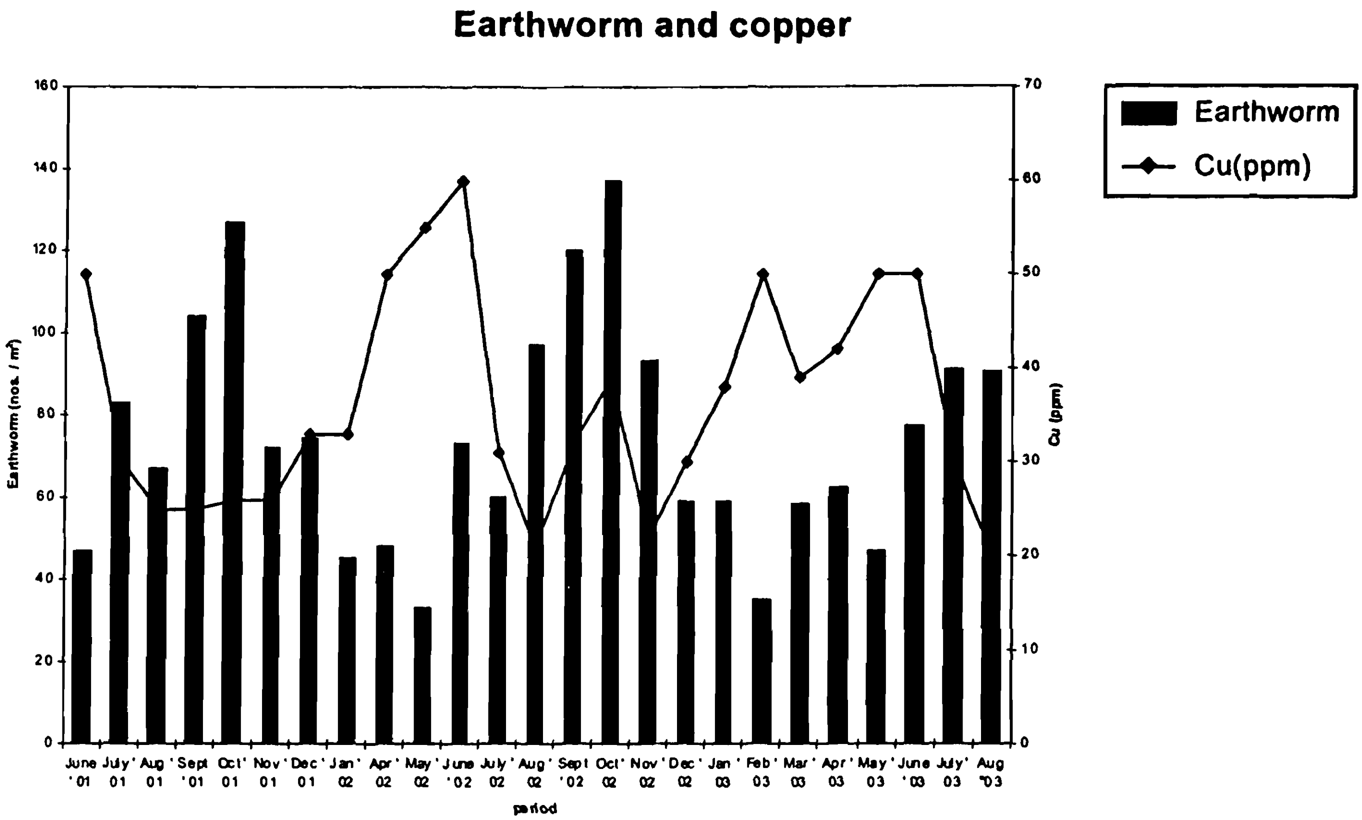


Fig. 41 : Showing monthly fluctuations of earthworm population and Copper at Site II (MD)

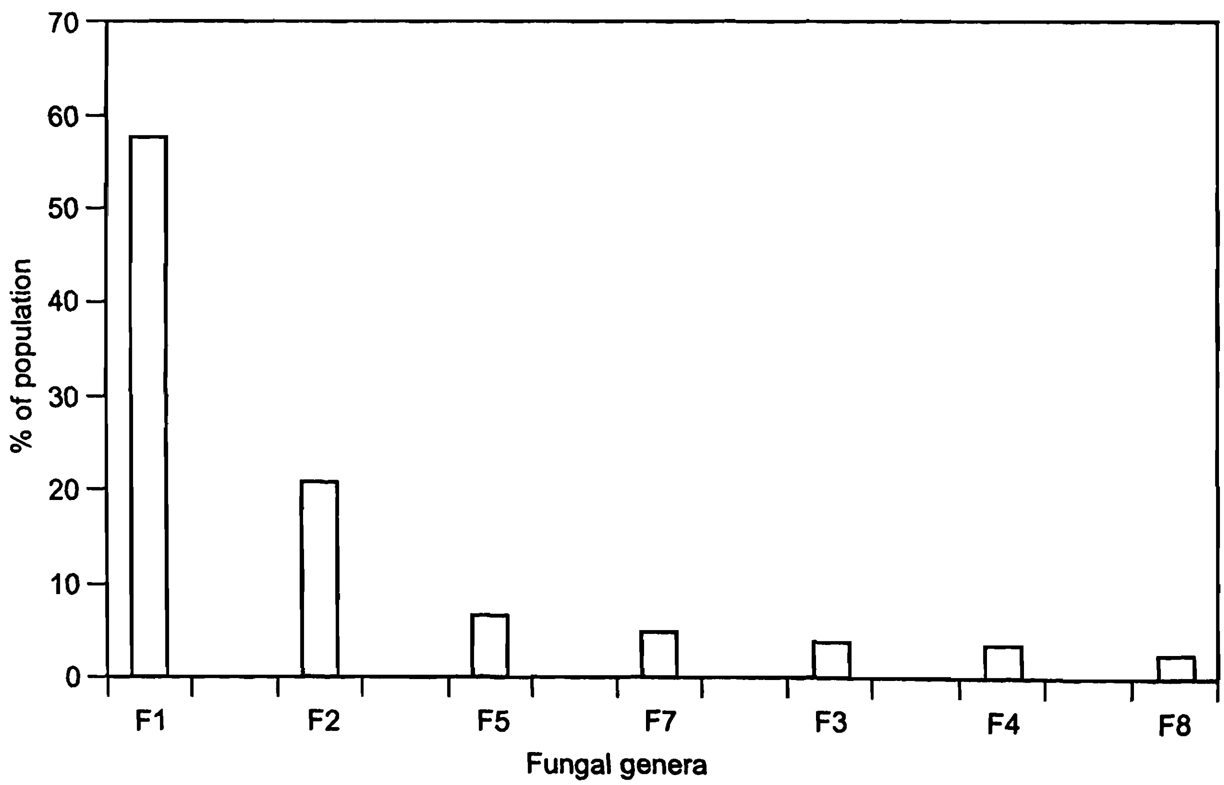


Fig. 42 : Showing composition of fungal community at Site II (MD)

Explanation : *F1 = Penicillium, F2 = Aspergillus, F3 = Fusarium, F4 = Trichoderma, F5 = Rhizopus, F7 = Mucor, F8 = Cladosporium*

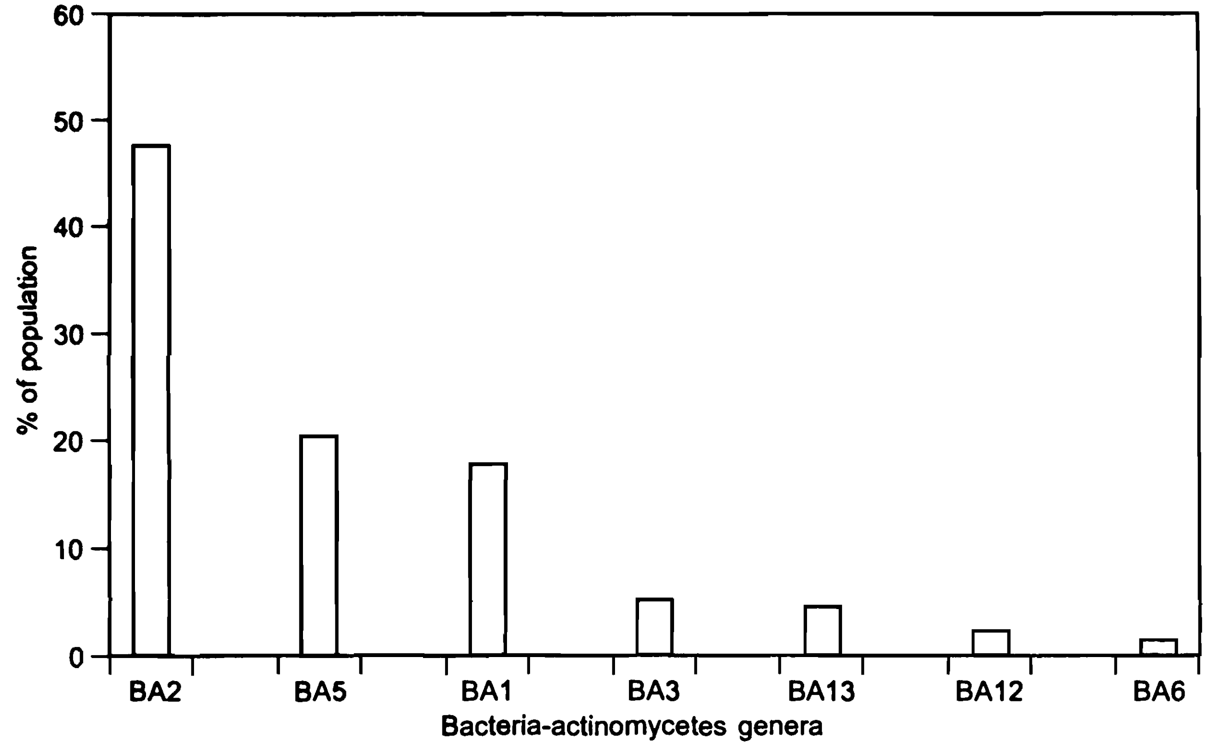


Fig. 43 : Showing composition of bacteria-actinomycetes community at Site II (MD)

Explanation : *BA1 = Bacillus, BA2 = Streptomyces, BA3 = Micrococcus I, BA5 = Arthrobacter, BA6 = Pseudomonas, BA12 = Azotobacter, BA13 = Nocardia*

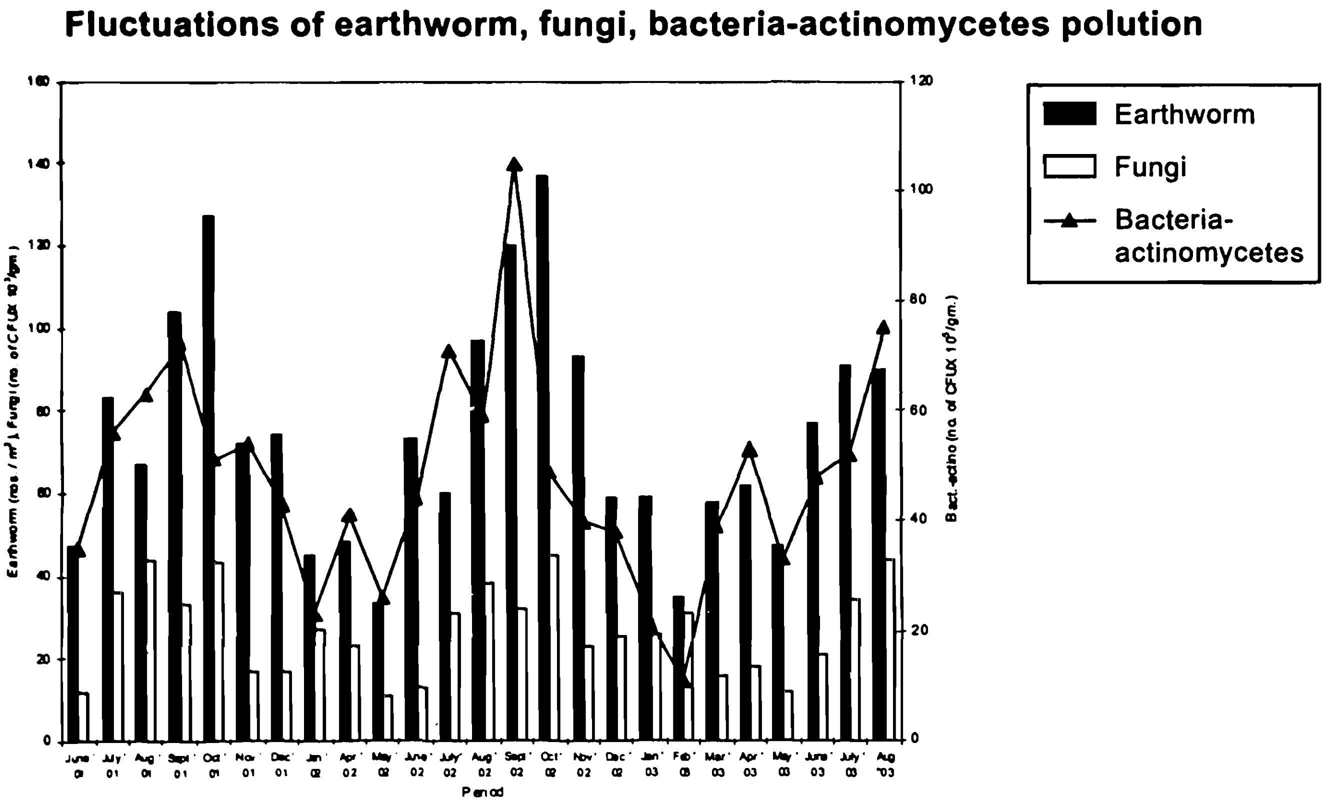


Fig. 44 : Showing monthly fluctuations of Earthworm, Fungi and Bacteria-actinomycetes population at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes population and subsoil temperature

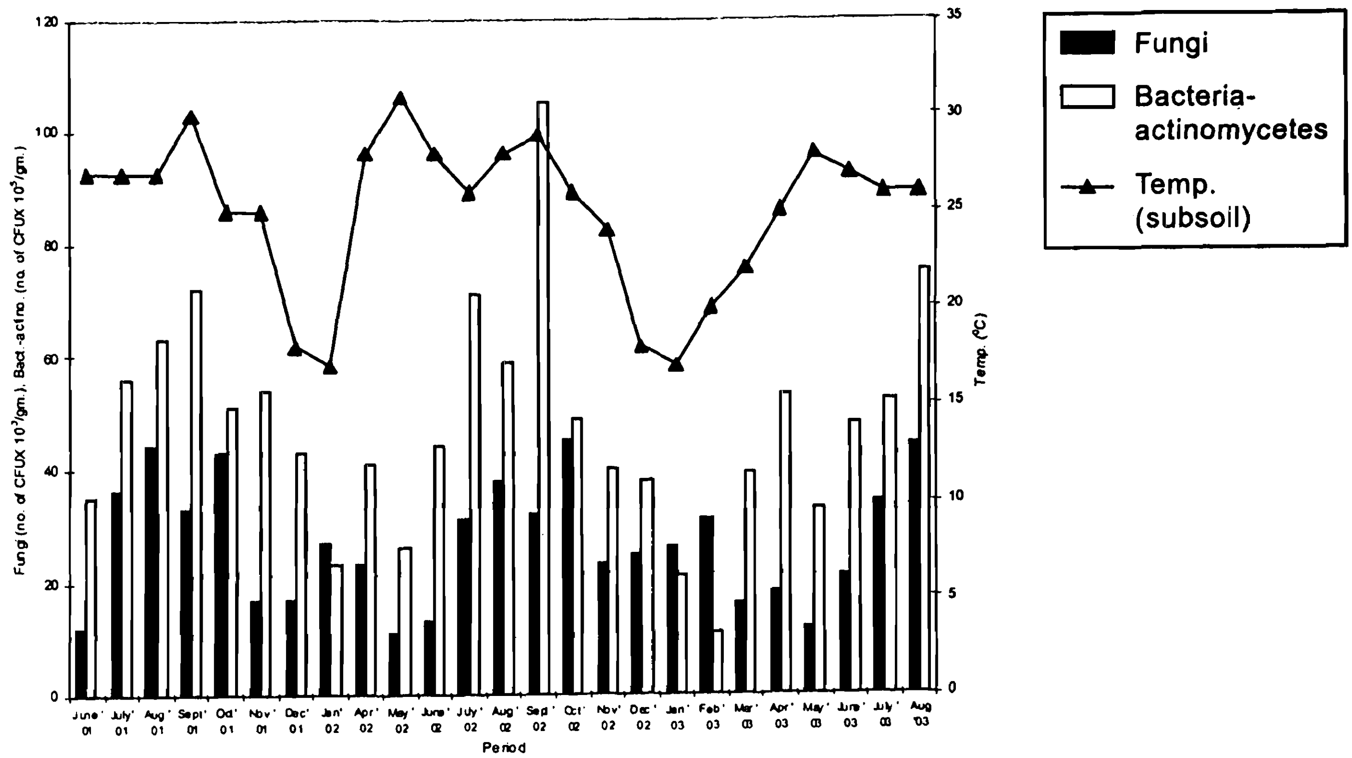


Fig. 45 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and subsoil temperature at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes population and subsoil humidity

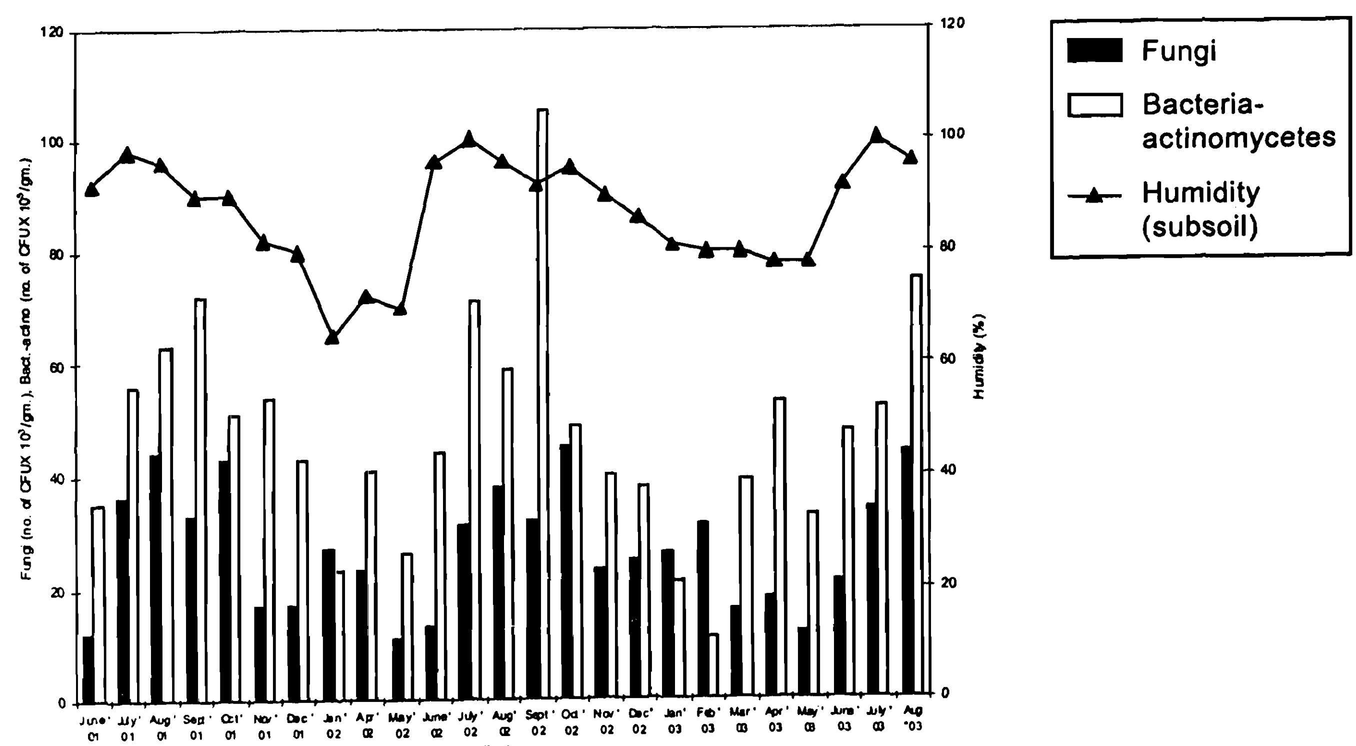


Fig. 46 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and subsoil relative humidity at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes polution and pH

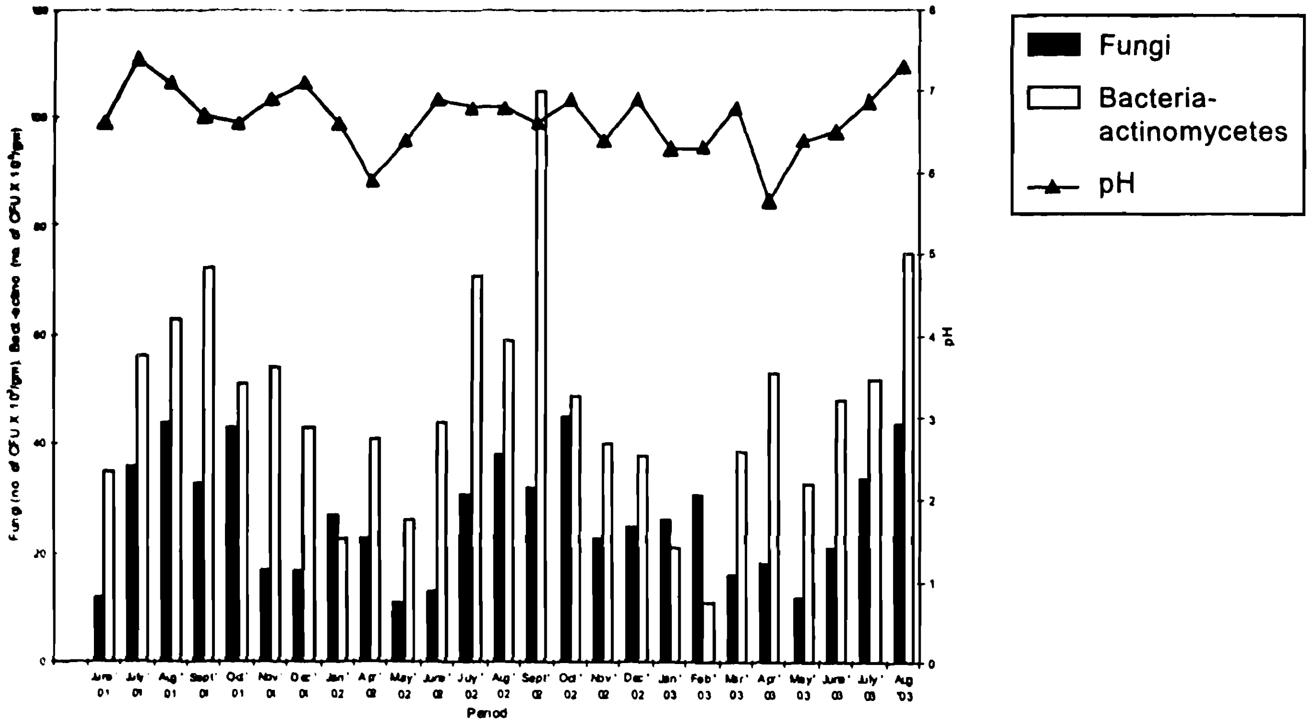


Fig. 47 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and pH at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes polution and E.C.

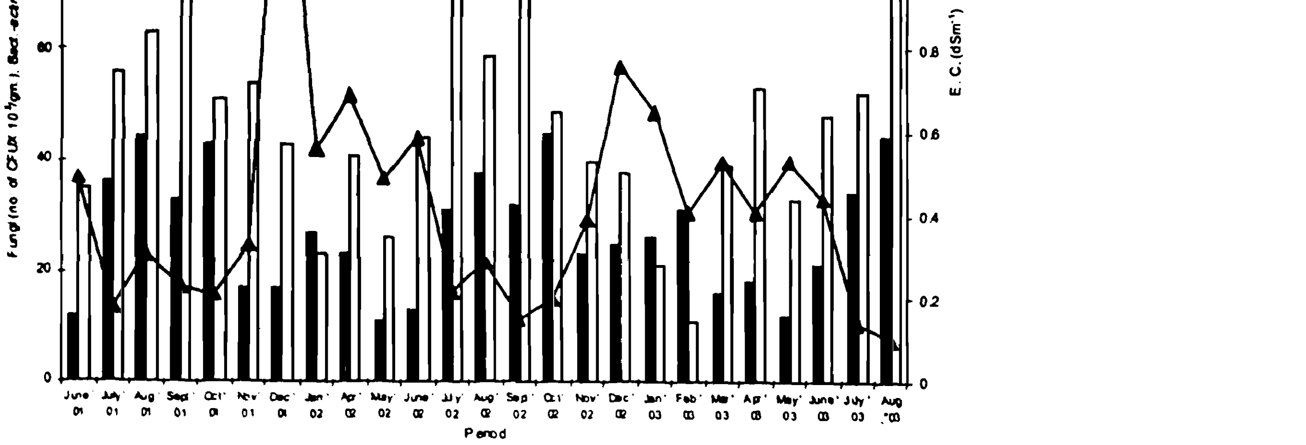


Fig. 48 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and electrical conductivity at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes population and organic carbon

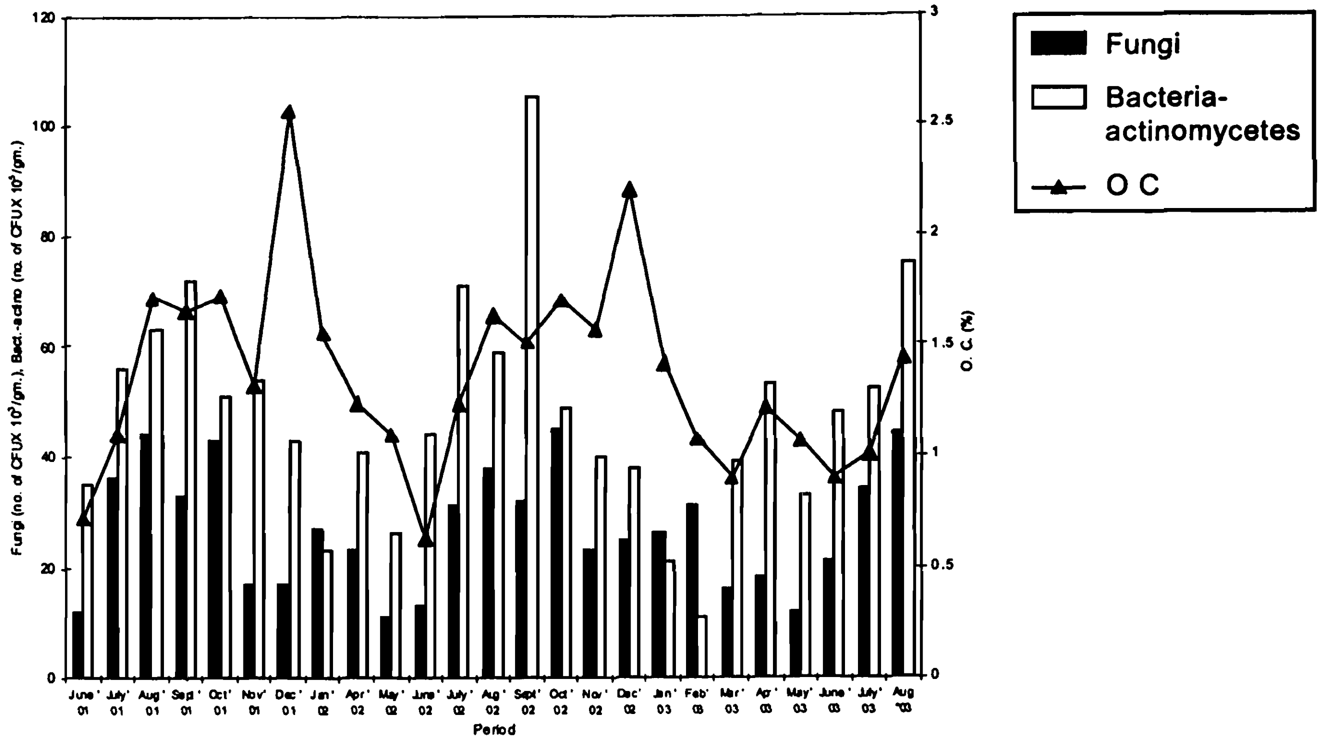


Fig. 49 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and organic Carbon at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes population and available N_2

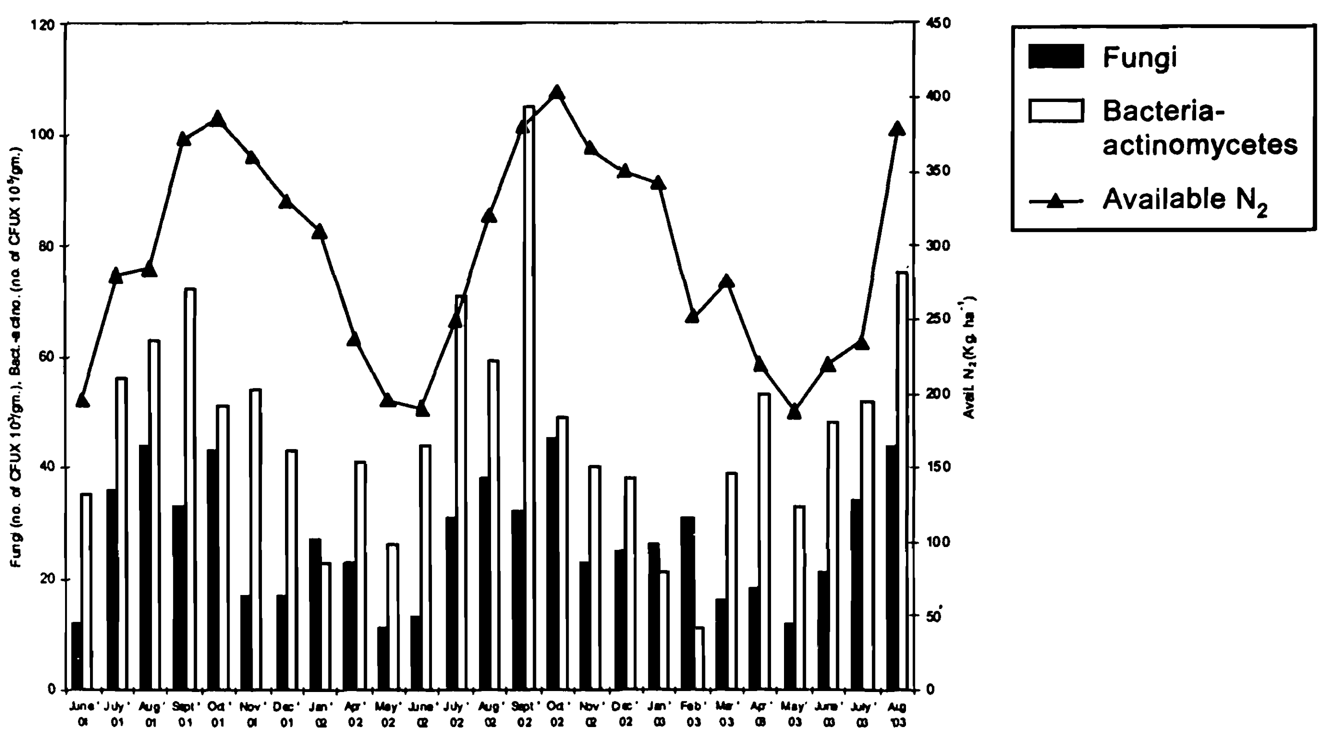


Fig. 50 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and available Nitrogen at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes polution and available P_2O_5

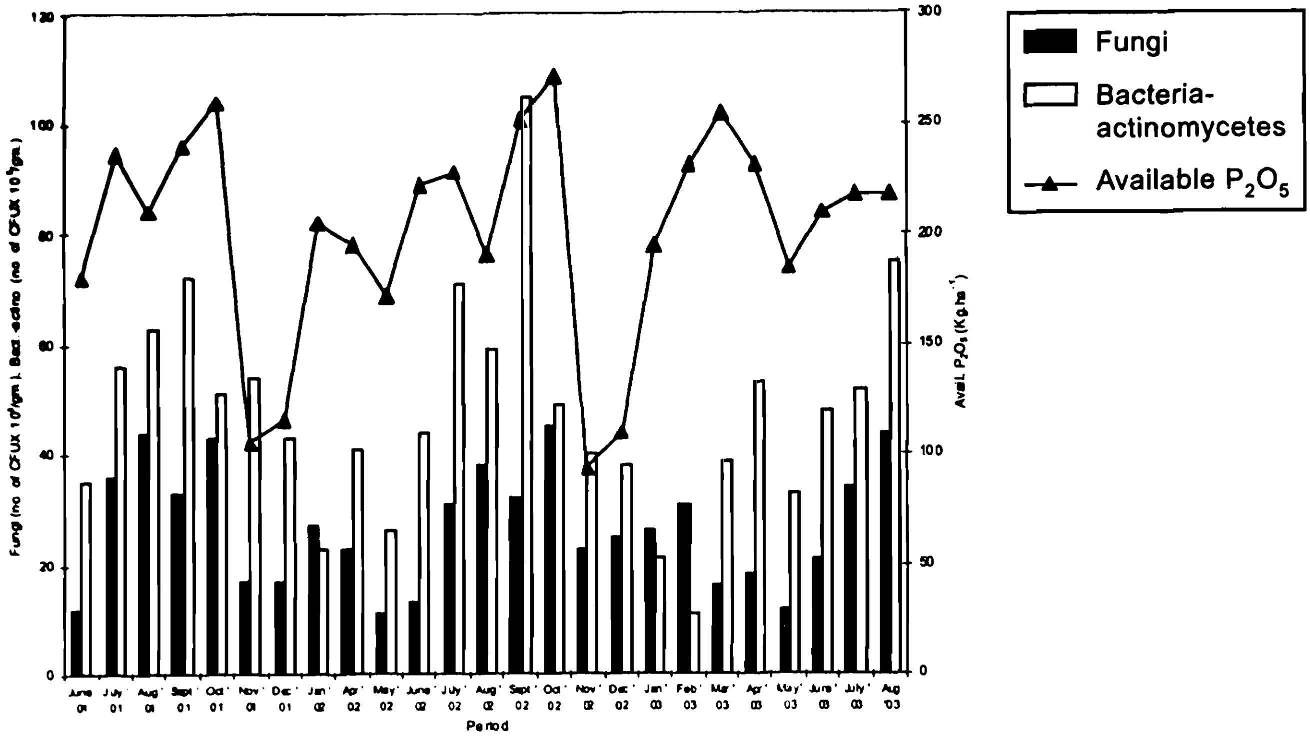


Fig. 51 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and available P_2O_5 at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes polution and available K_2O

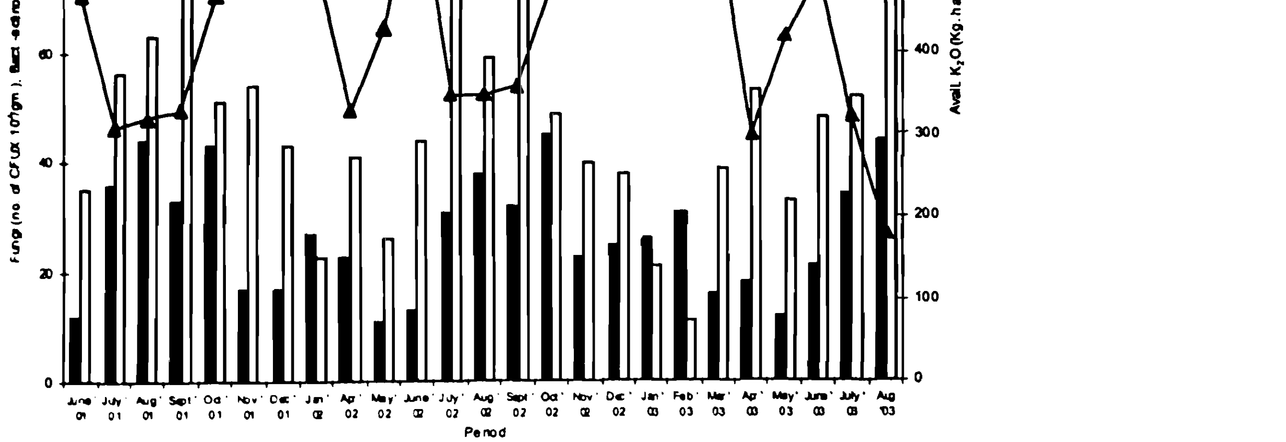


Fig. 52 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and available K_2O at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes population and Cadmium

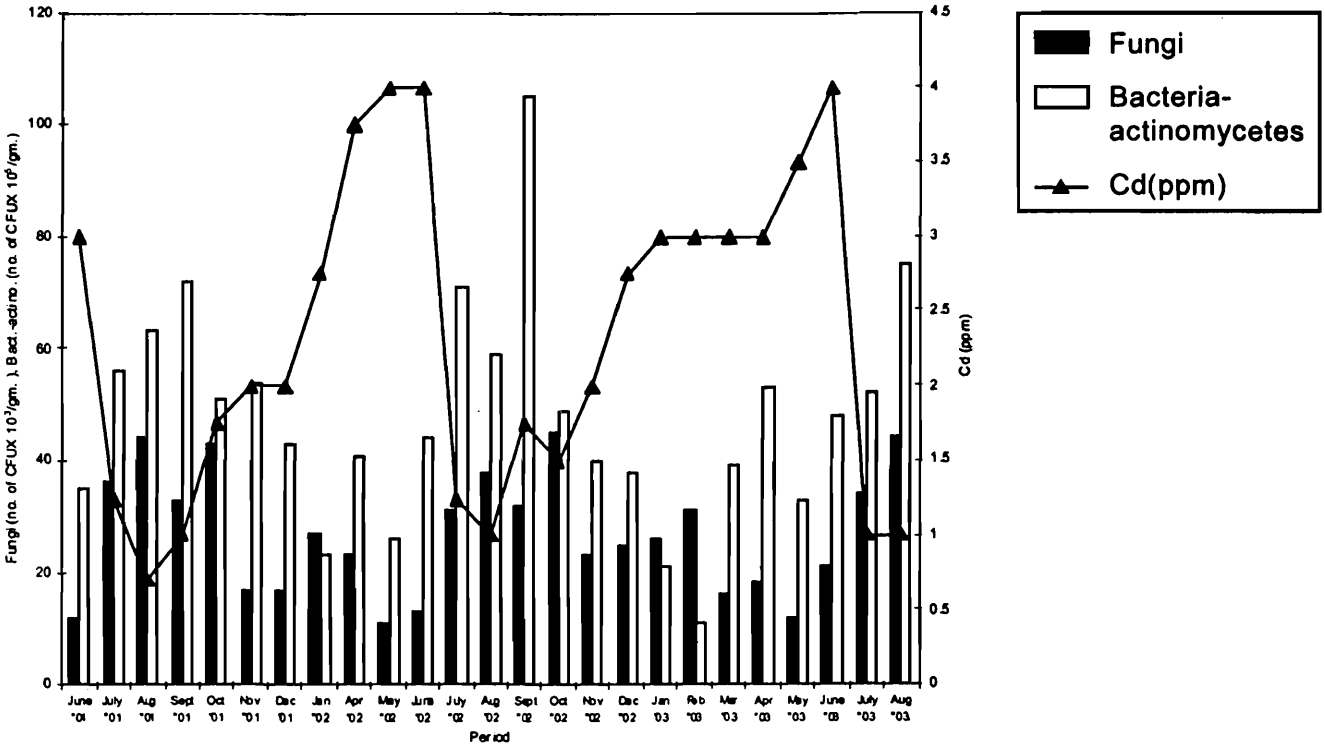


Fig. 53 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Cadmium at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes population and Zinc

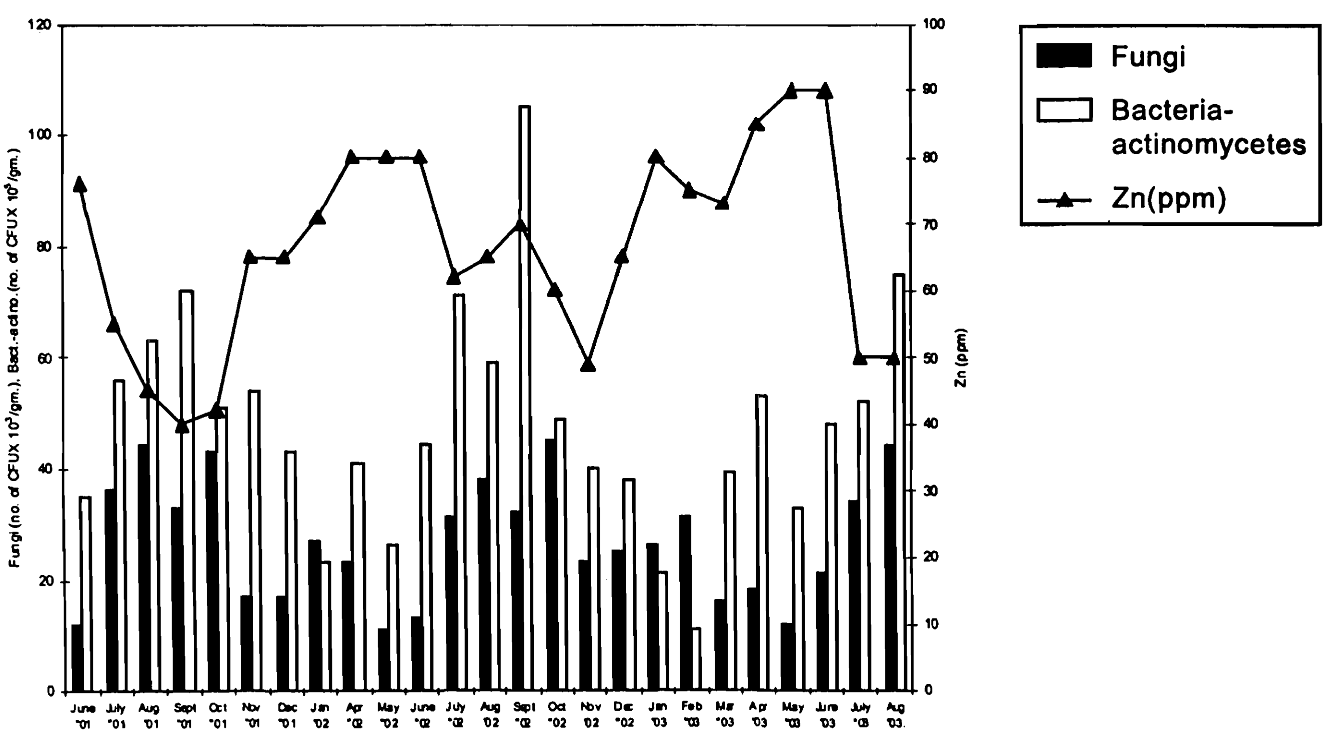


Fig. 54 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Zinc at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes polution and Lead

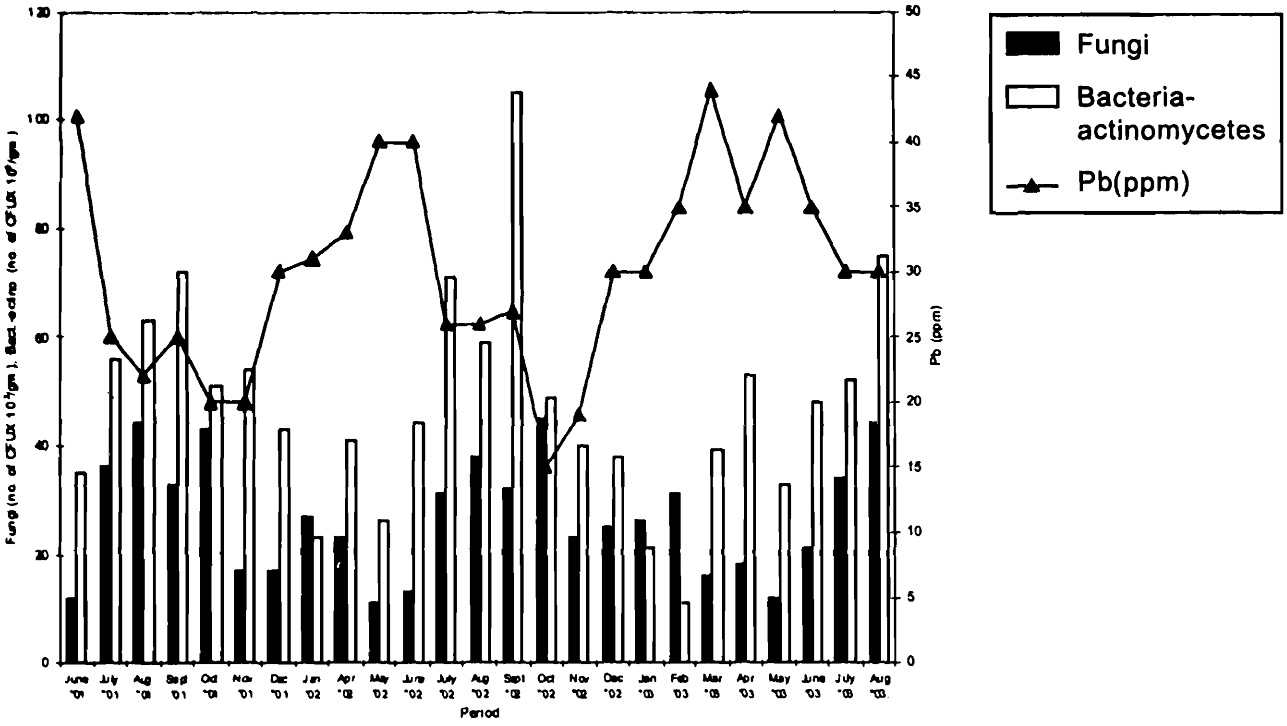


Fig. 55 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Lead at Site II (MD)

Fluctuations of fungi, bacteria-actinomycetes polution and Copper

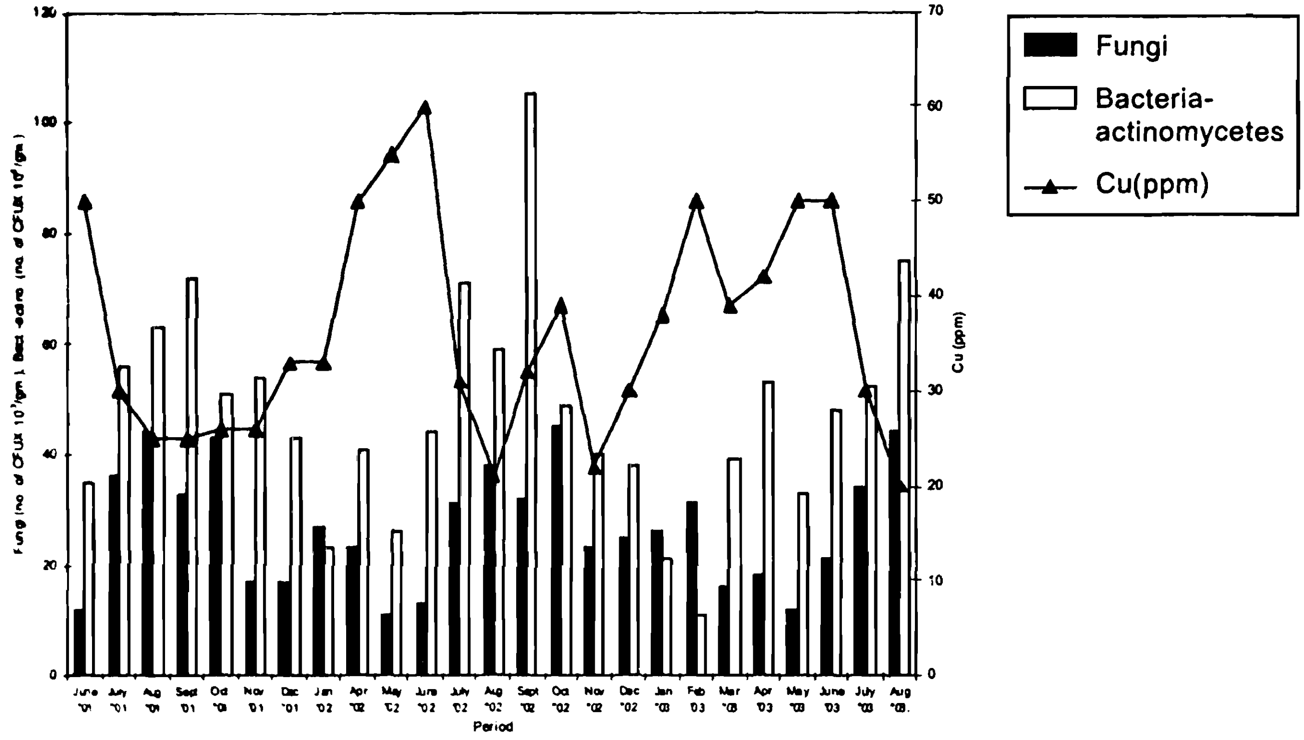


Fig. 56 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Copper at Site II (MD)

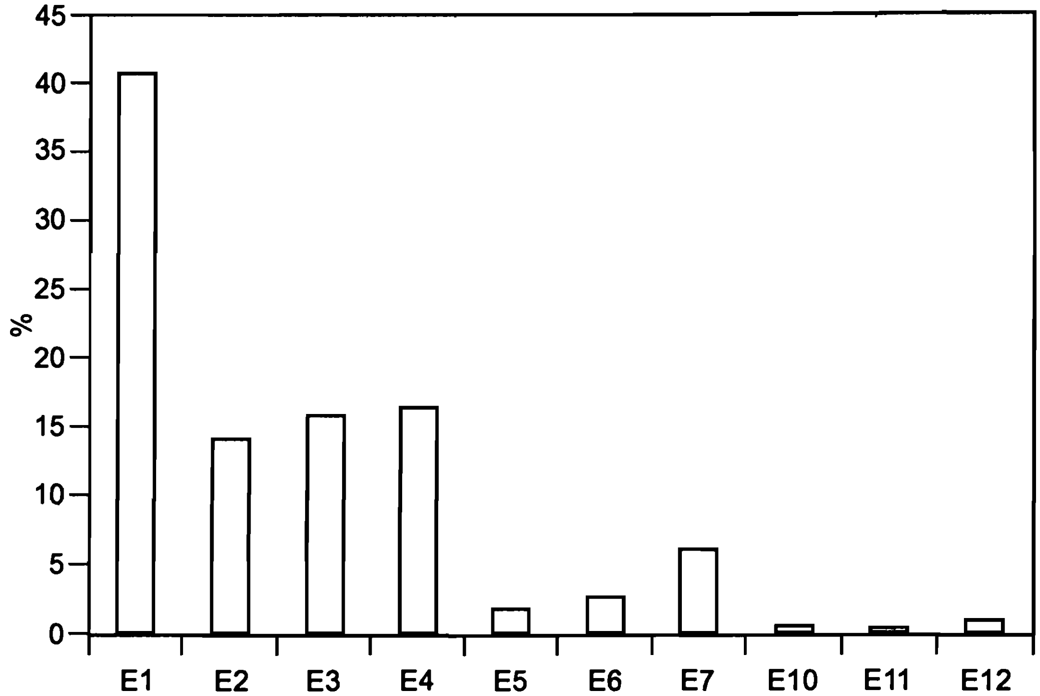


Fig. 57 : Showing composition of earthworm community at Site III (BRF)

Explanation : *E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E6 = Eutyphoeus nicholsoni; E7 = Drawida nepalensis; E10 = Metaphire houlleti; E11 = Amynthas corticis; E12 = Octochaetona beatrix*

Earthworm and subsoil temp.

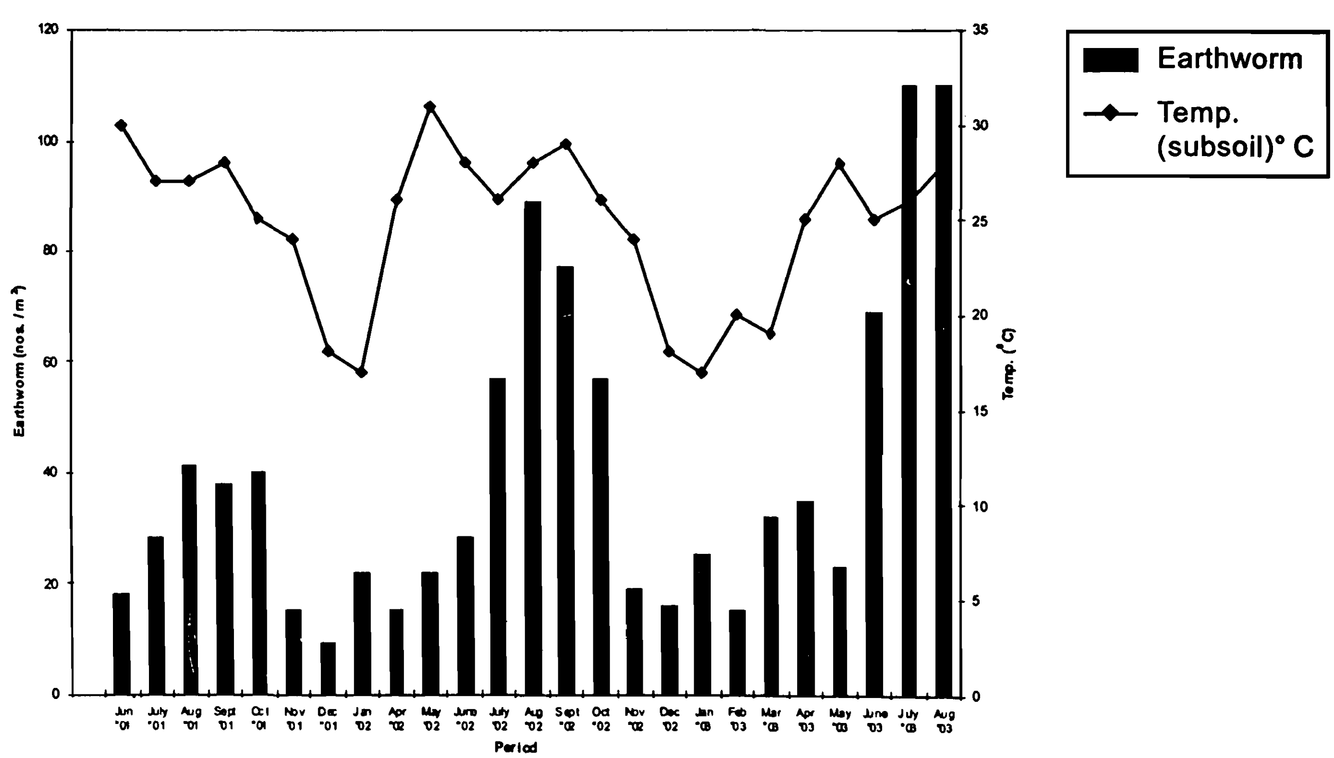


Fig. 58 : Showing monthly fluctuations of earthworm population and subsoil temperature at Site III (BRF)

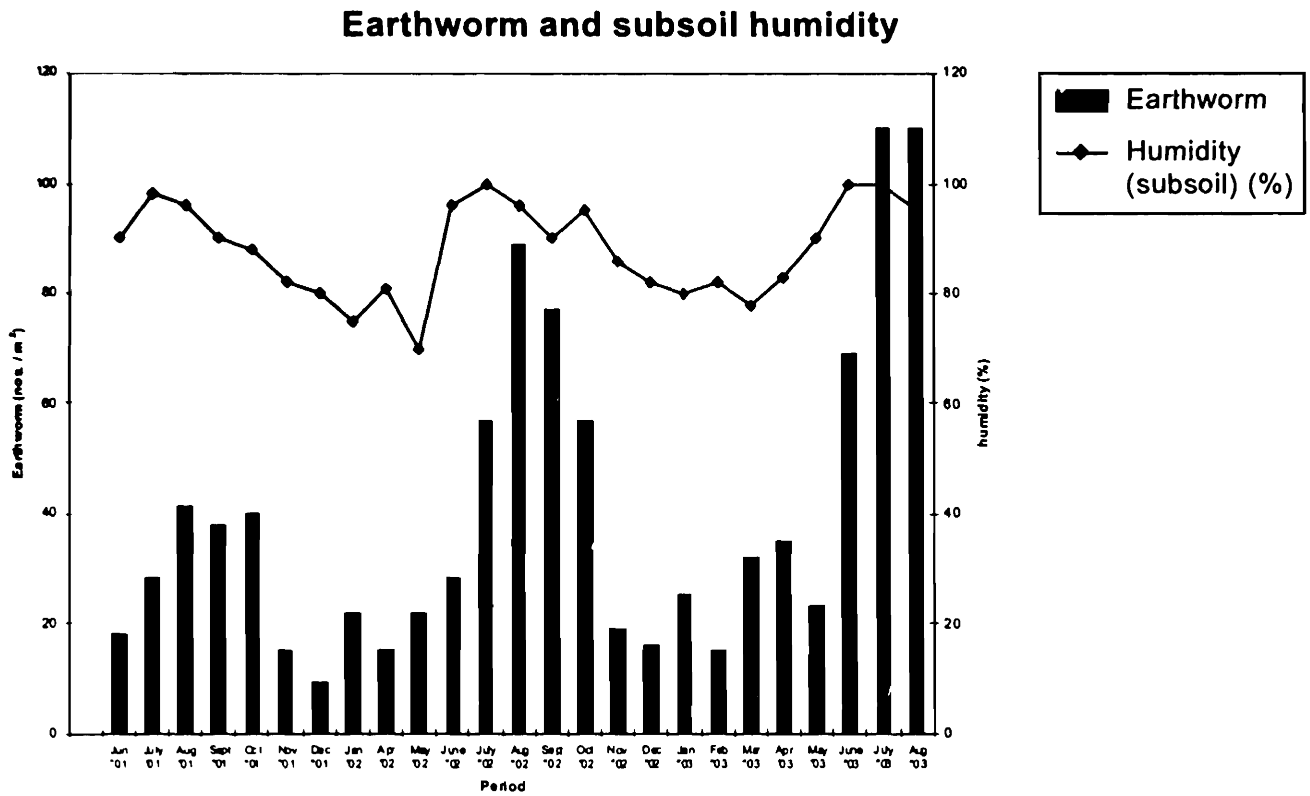


Fig. 59 : Showing monthly fluctuations of earthworm population and subsoil relative humidity at Site III (BRF)

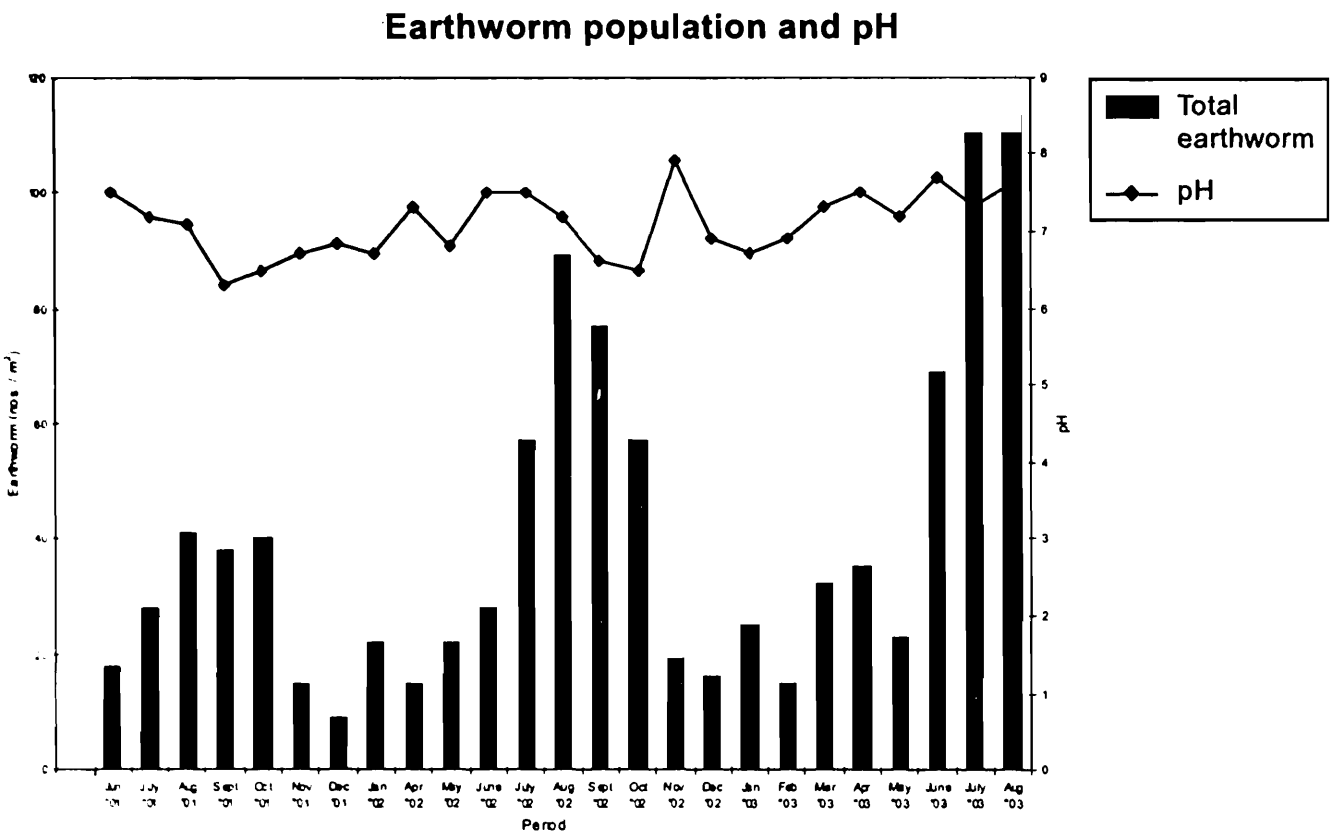


Fig. 60 : Showing monthly fluctuations of earthworm population and pH at Site III (BRF)

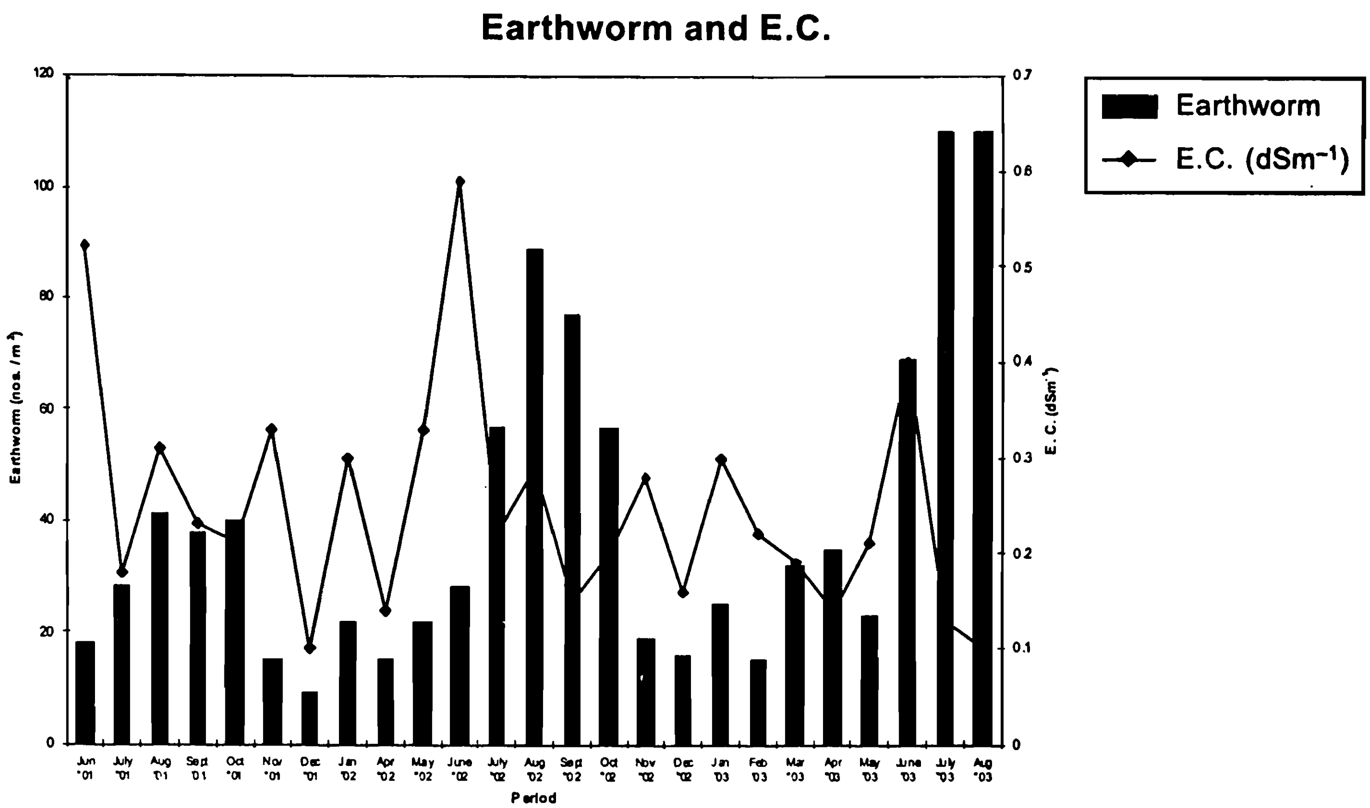


Fig. 61 : Showing monthly fluctuations of earthworm population and electrical conductivity at Site III (BRF)

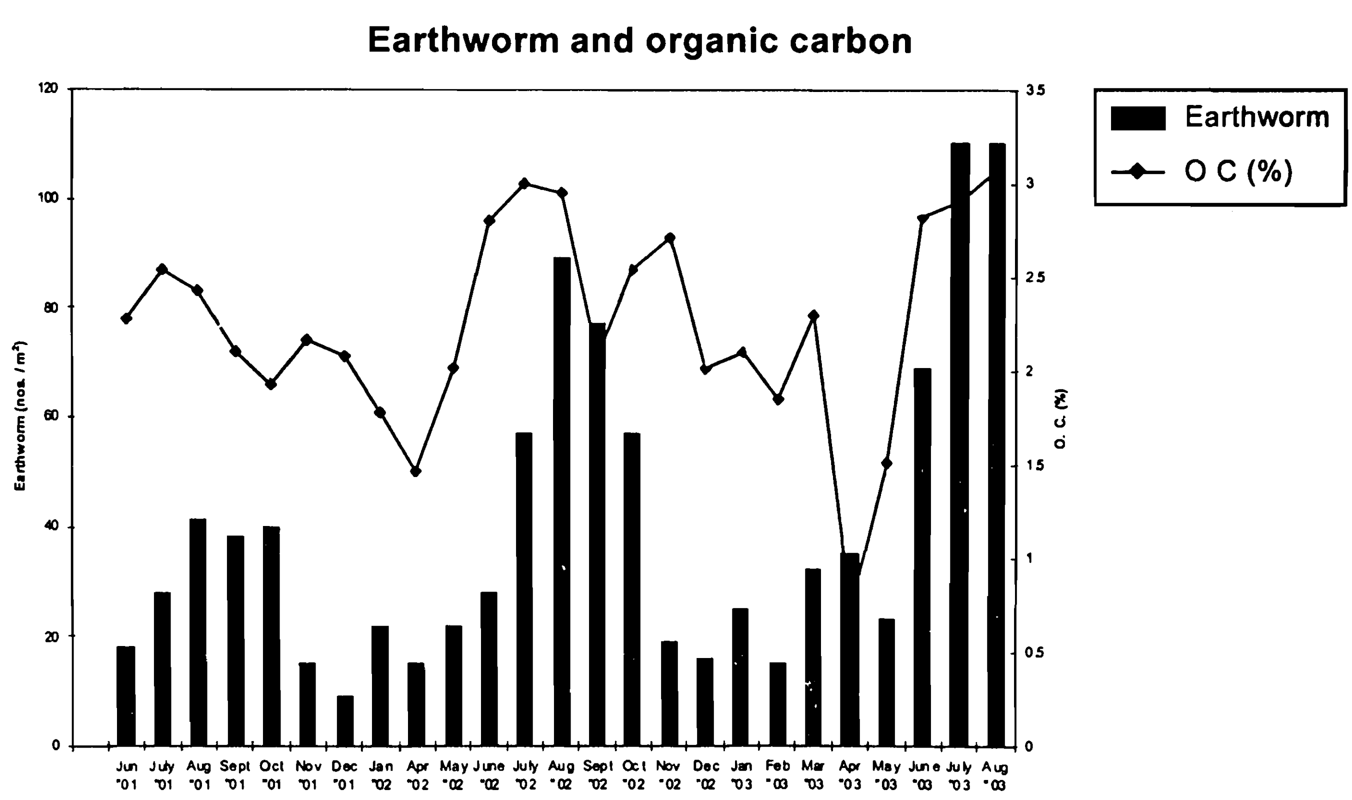


Fig. 62 : Showing monthly fluctuations of earthworm population and organic Carbon at Site III (BRF)

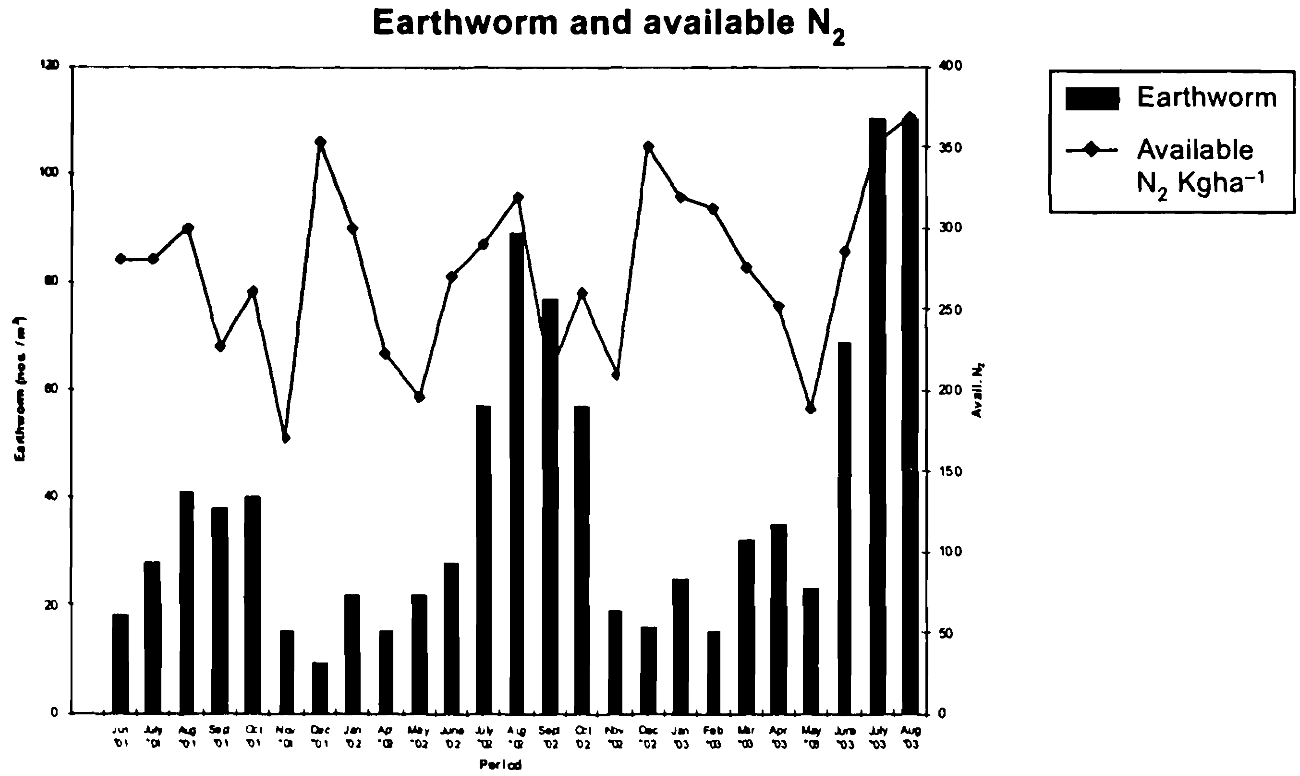


Fig. 63 : Showing monthly fluctuations of earthworm population and available Nitrogen at Site III (BRF)

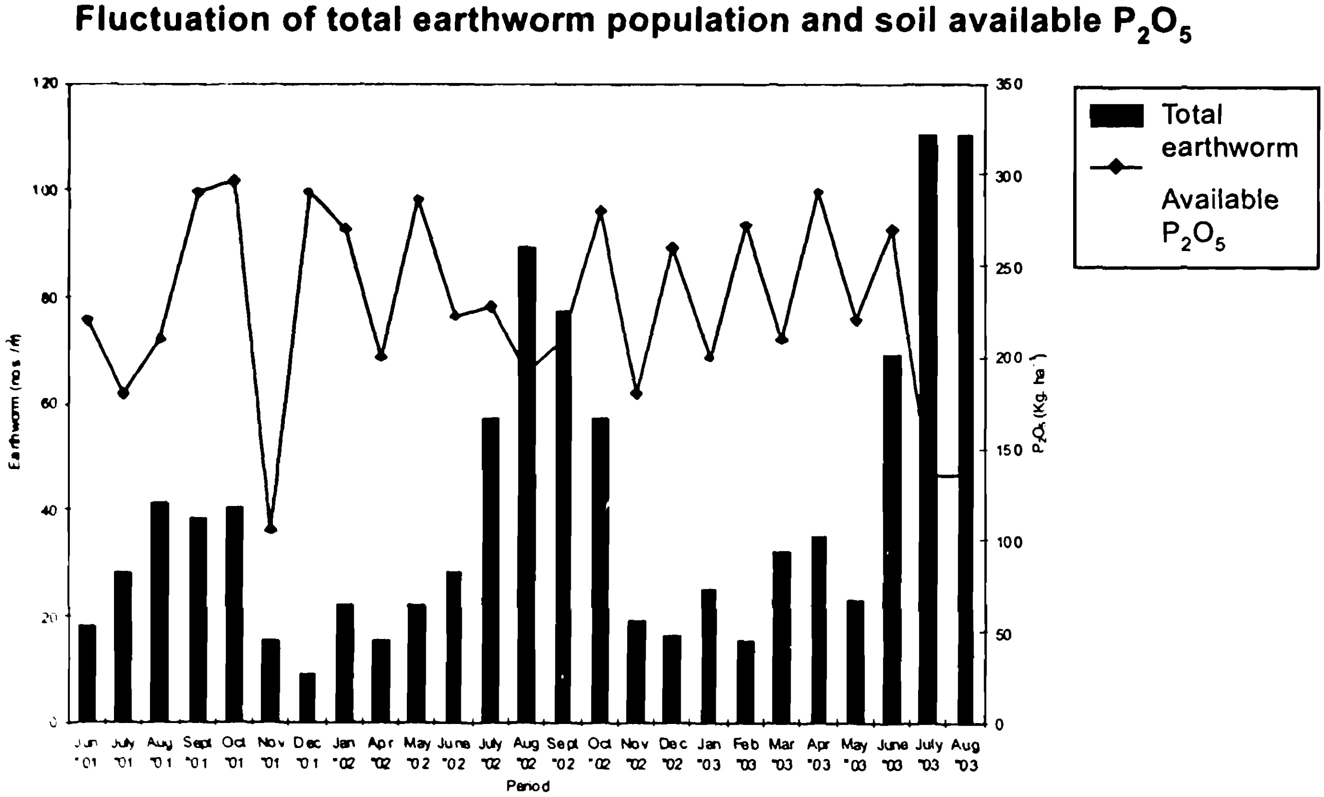


Fig. 64 : Showing monthly fluctuations of earthworm population and available P_2O_5 at Site III (BRF)

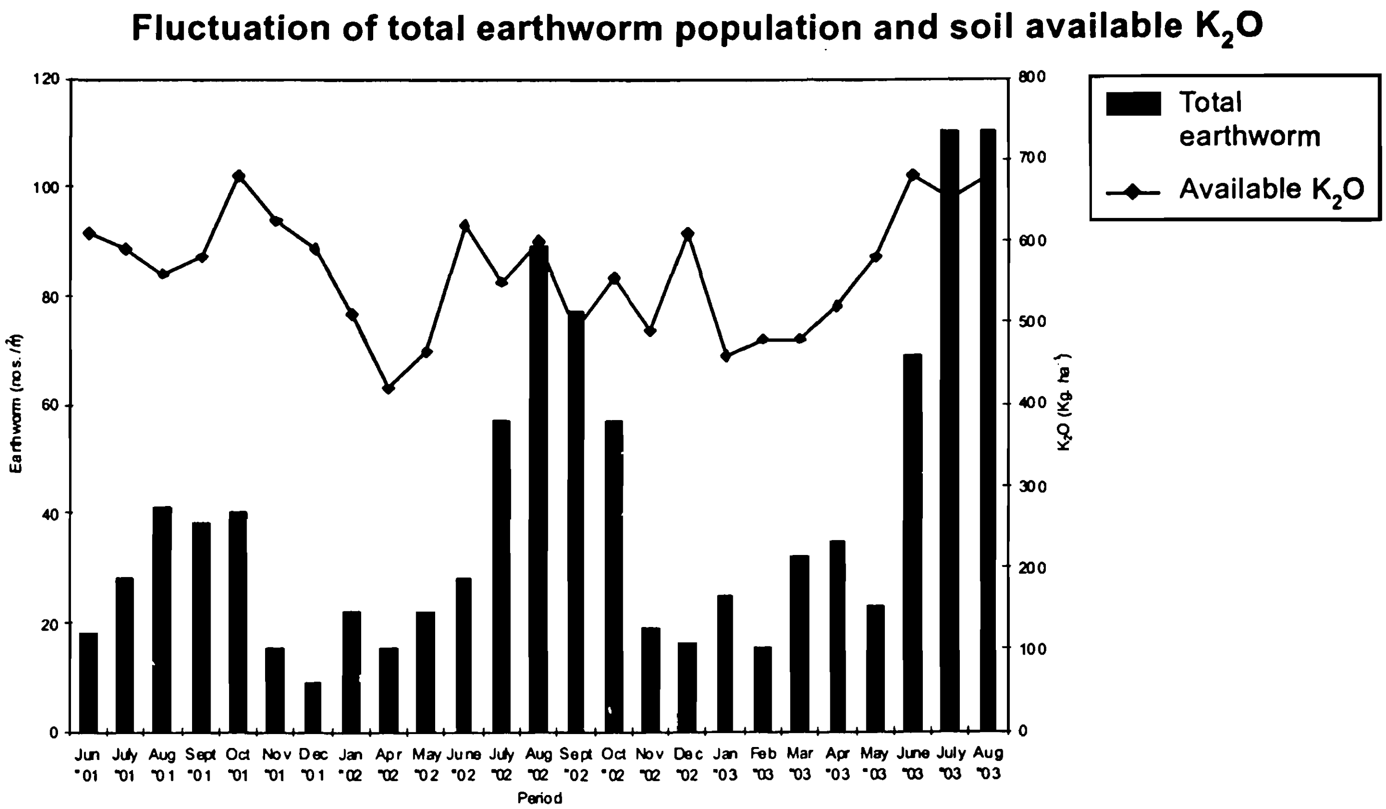


Fig. 65 : Showing monthly fluctuations of earthworm population and available K_2O at Site III (BRF)

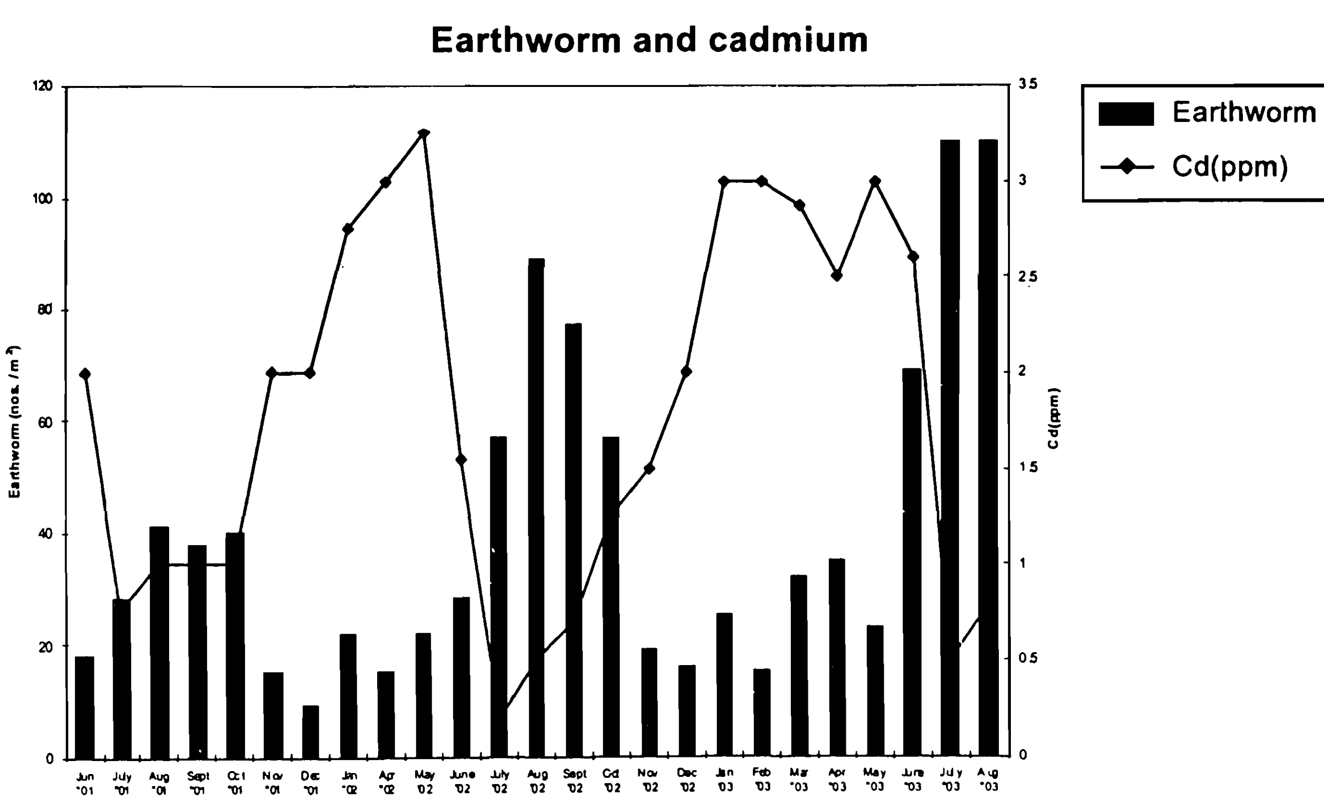


Fig. 66 : Showing monthly fluctuations of earthworm population and Cadmium at Site III (BRF)

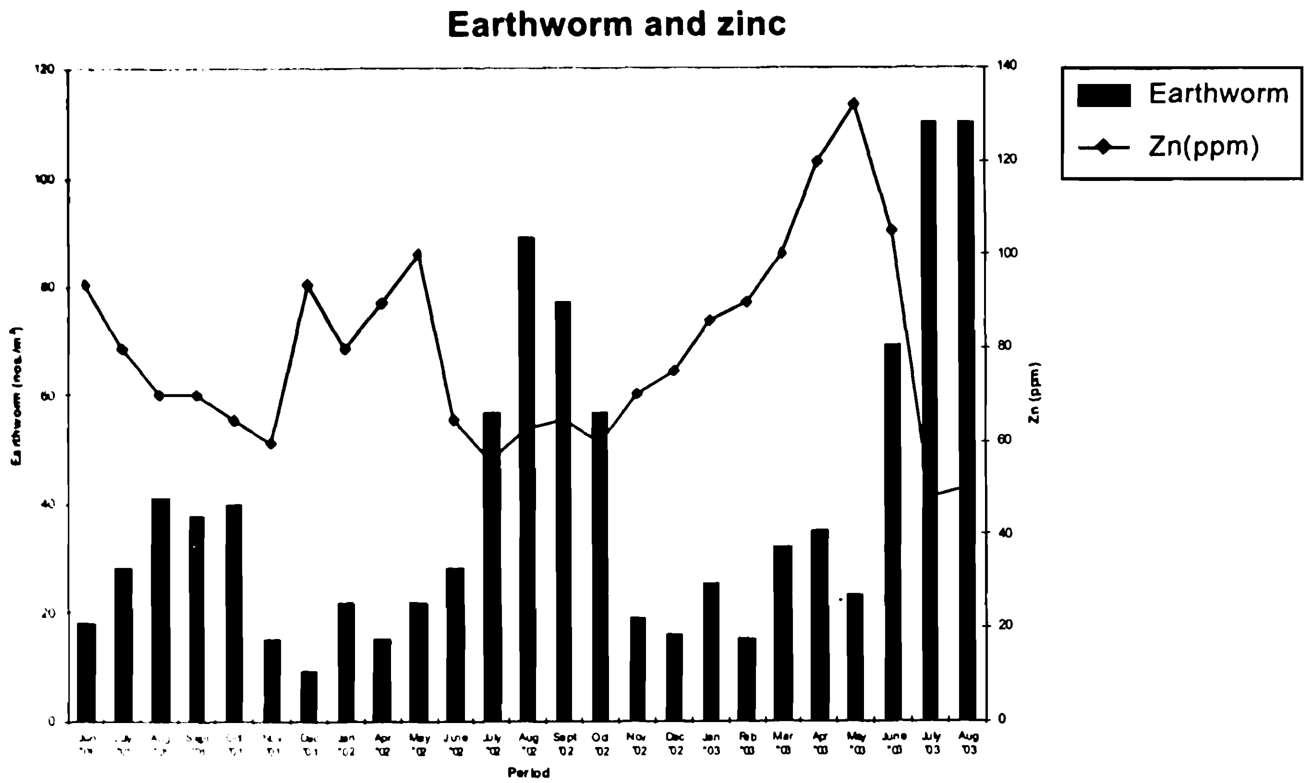


Fig. 67 : Showing monthly fluctuations of earthworm population and Zinc at Site III (BRF)

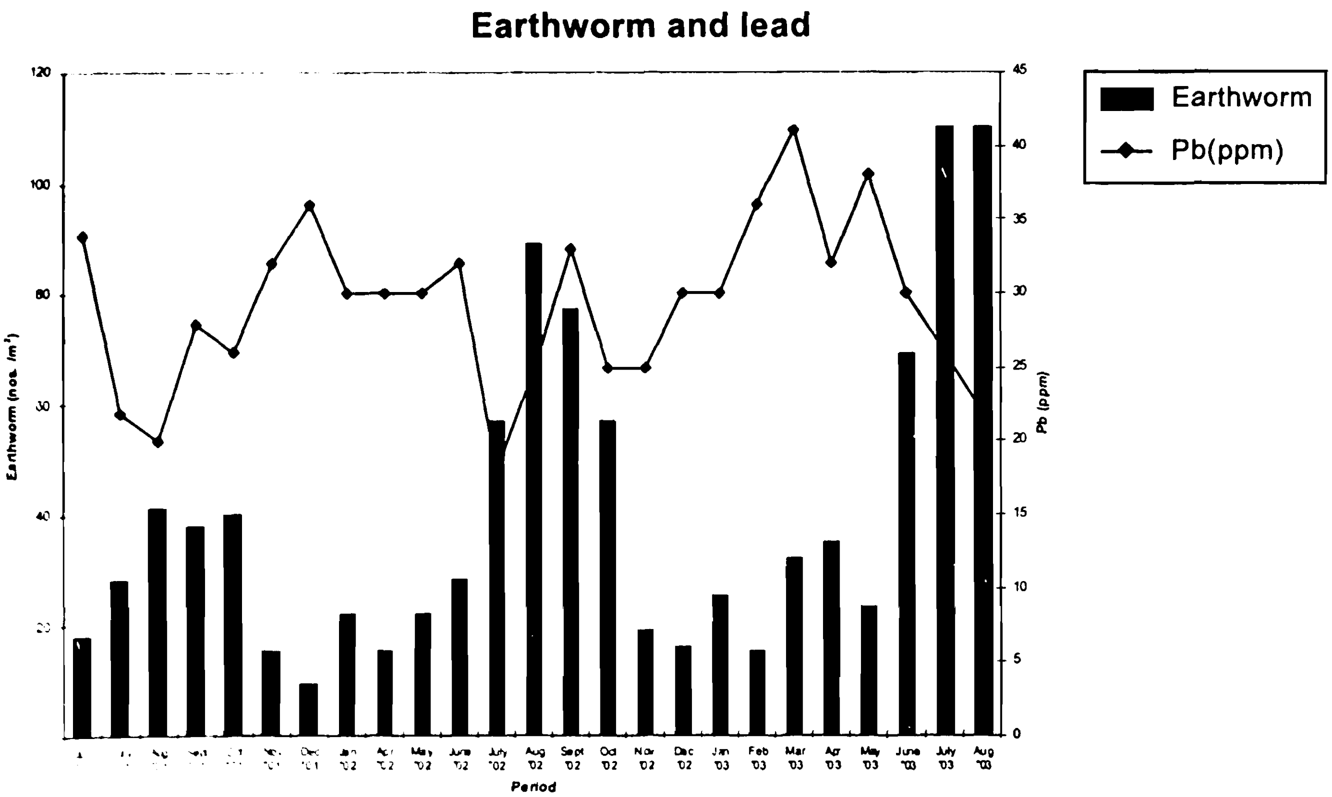


Fig. 68 : Showing monthly fluctuations of earthworm population and Lead at Site III (BRF)

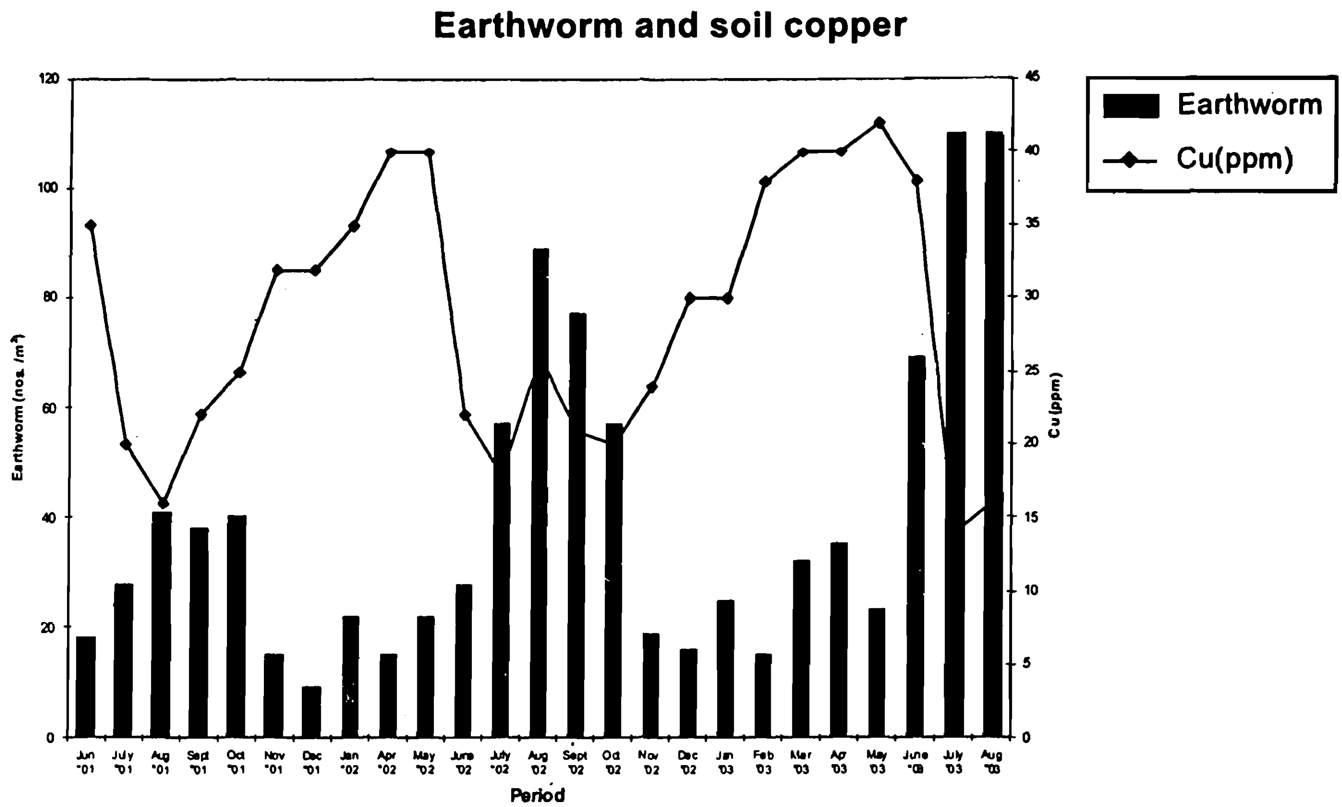


Fig. 69 : Showing monthly fluctuations of earthworm population and Copper at Site III (BRF)

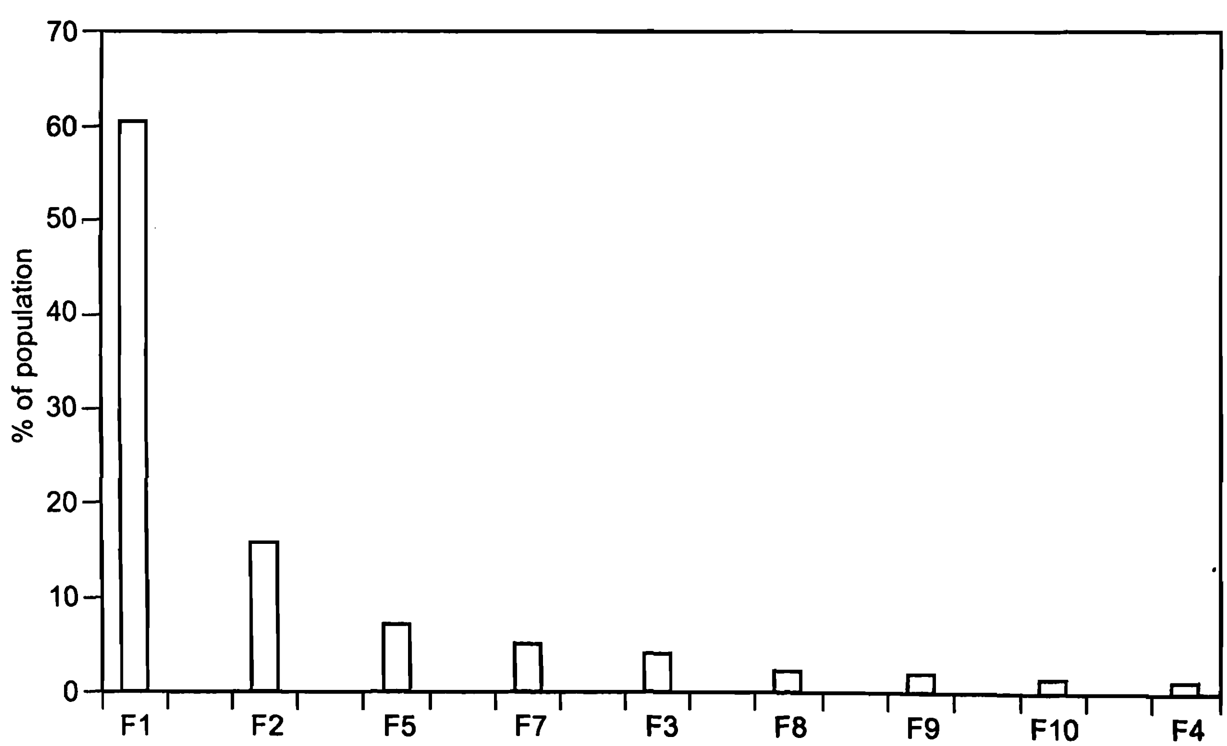


Fig. 70 : Showing composition of fungal community at Site III (BRF)

Explanation : *F1 = Penicillium, F2 = Aspergillus, F3 = Fusarium, F4 = Trichoderma, F5 = Rhizopus, F7 = Mucor, F8 = Cladosporium, F9 = Sclerotium, F10 = Curvularia*

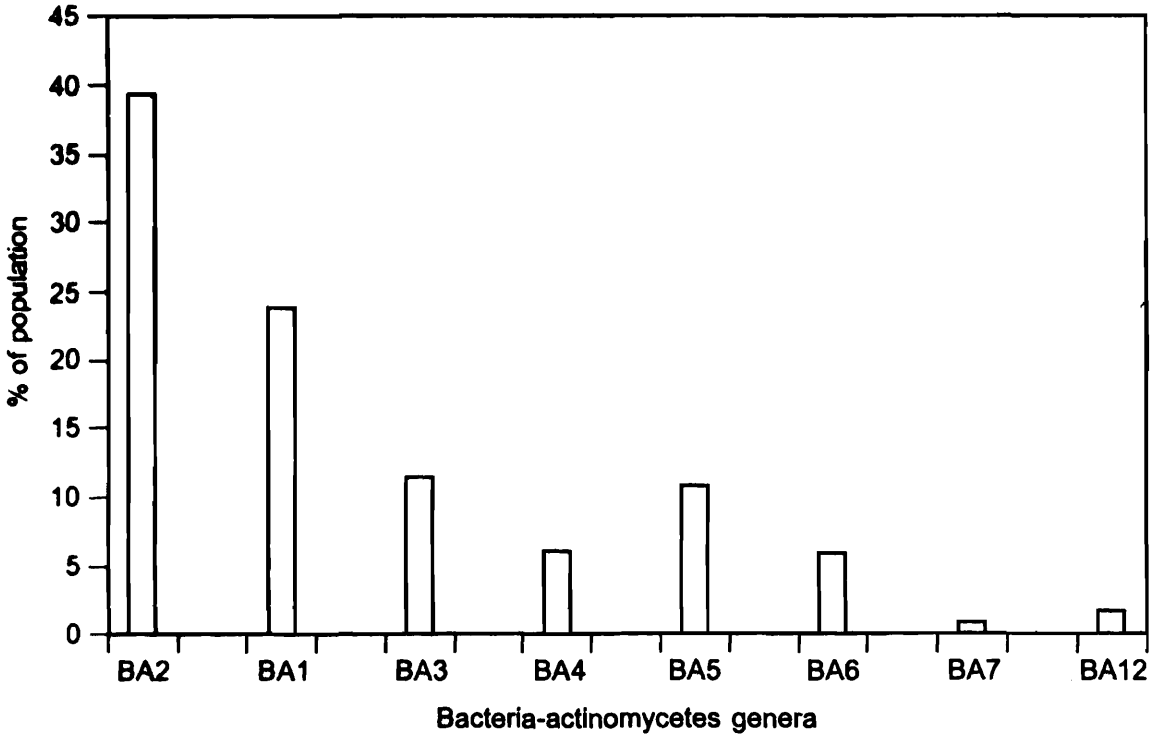


Fig. 71 : Showing composition of bacteria-actinomycetes community at Site III (BRF)

Explanation : *BA1 = Bacillus, BA2 = Streptomyces, BA3 = Micrococcus I, BA4 = Micrococcus II, BA5 = Arthrobacter, BA6 = Pseudomonas, BA7 = Promicromonospora, BA12 = Azotobacter*

Fluctuations of earthworm, fungi and bacteria-actinomycetes population

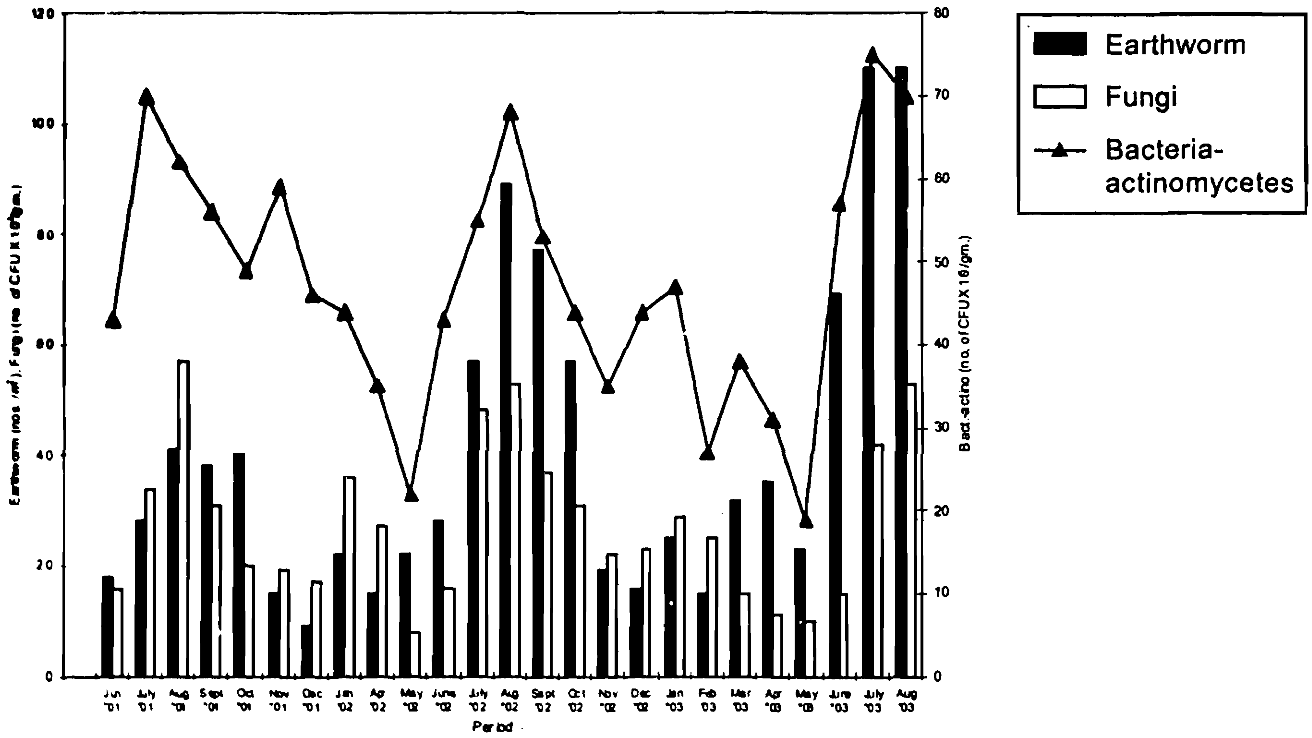


Fig. 72 : Showing monthly fluctuations of Earthworm, Fungi and Bacteria-actinomycetes population at Site III (BRF)

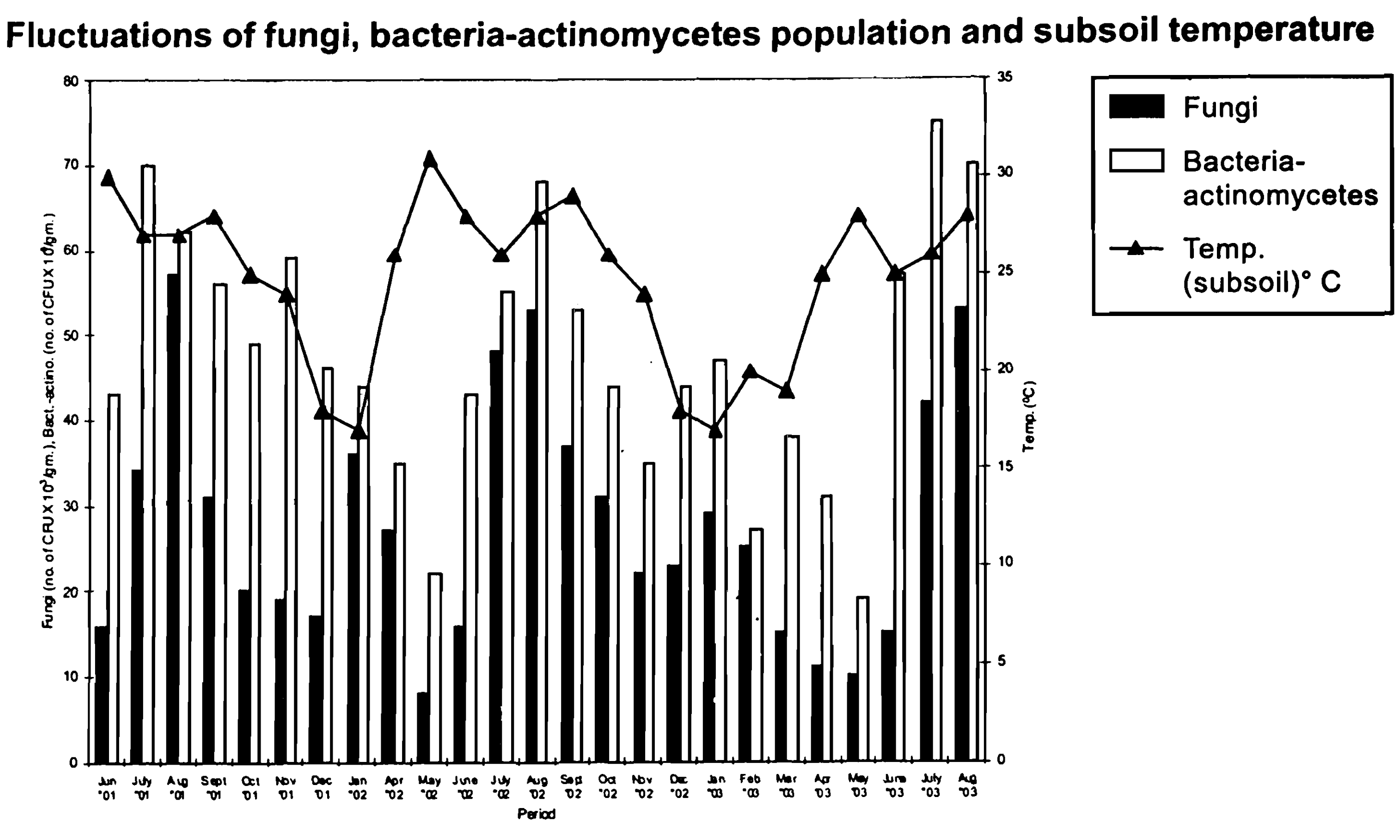


Fig. 73 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and subsoil temperature at Site III (BRF)

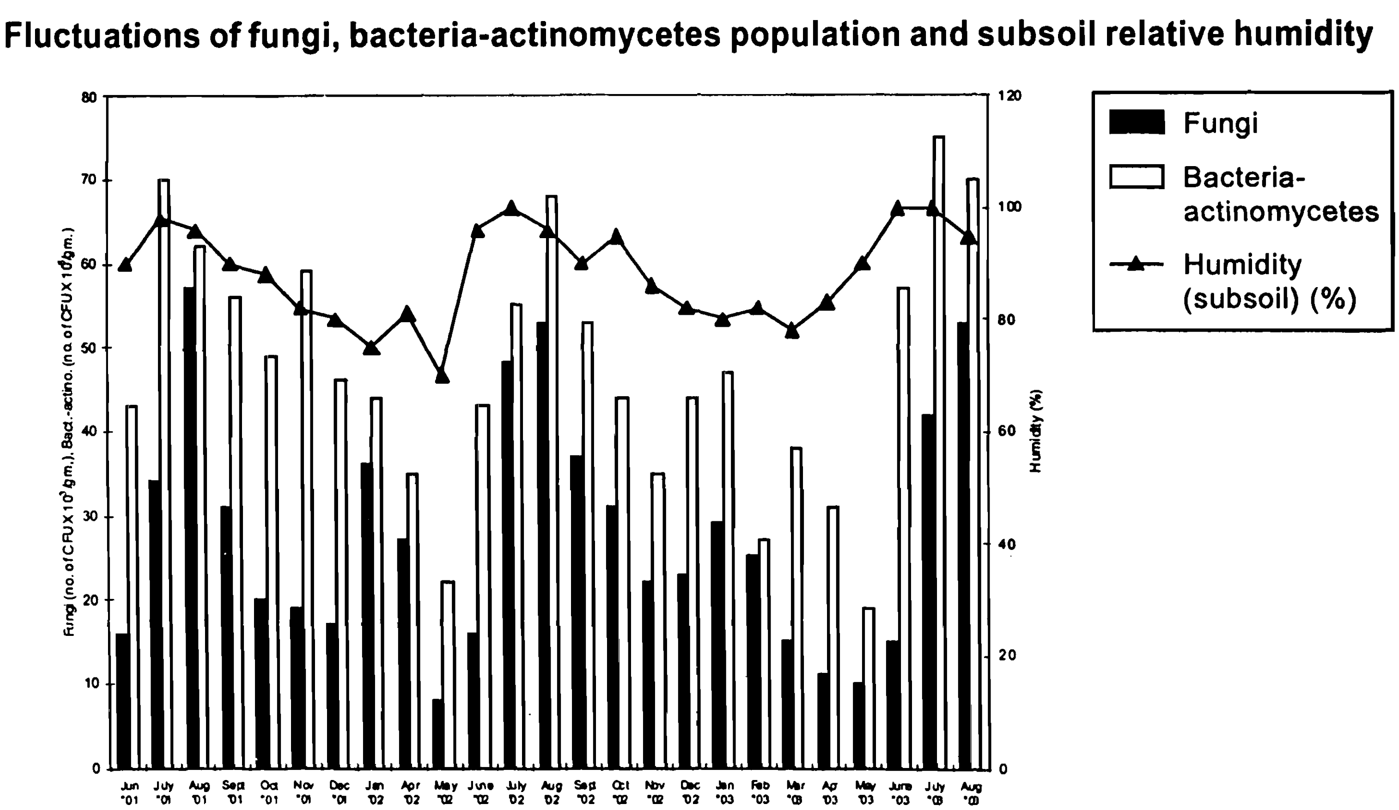


Fig. 74 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and subsoil relative humidity at Site III (BRF)

Fluctuations of fungi, bacteria-actinomycetes population and pH

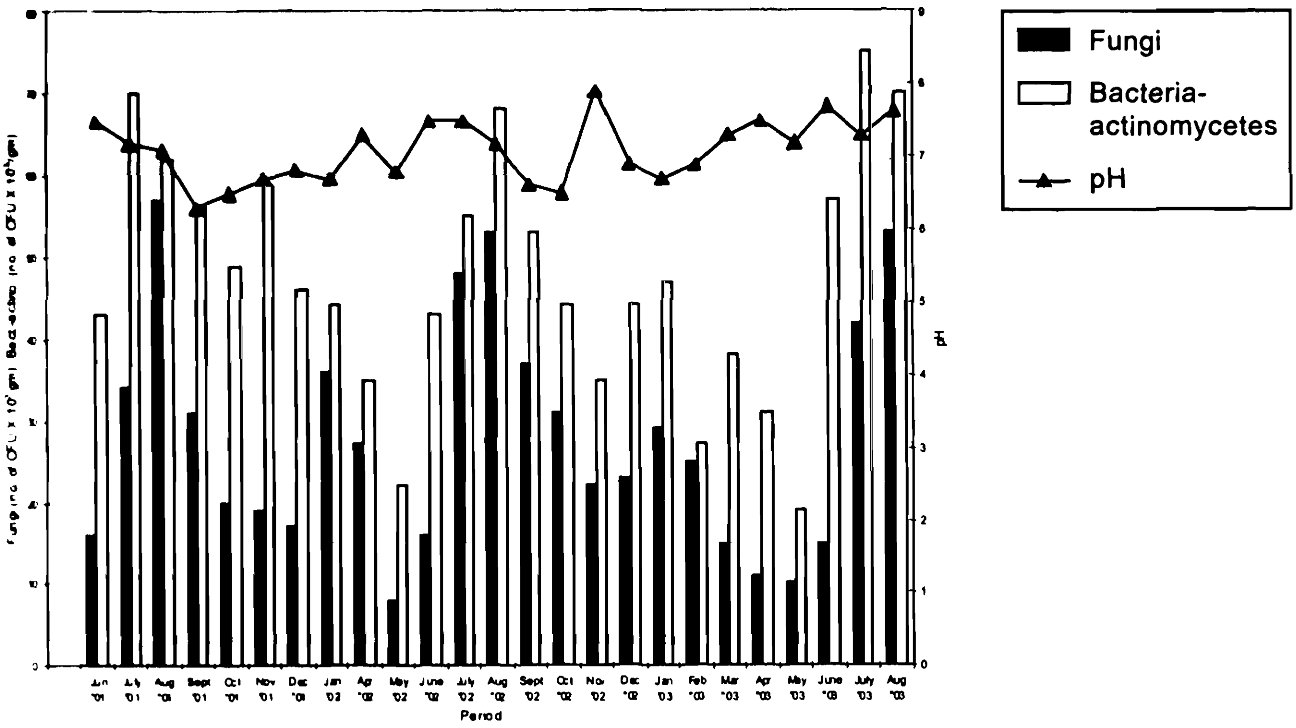


Fig. 75 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and pH at Site III (BRF)

Fluctuations of fungi, bacteria-actinomycetes population and electrical conductivity

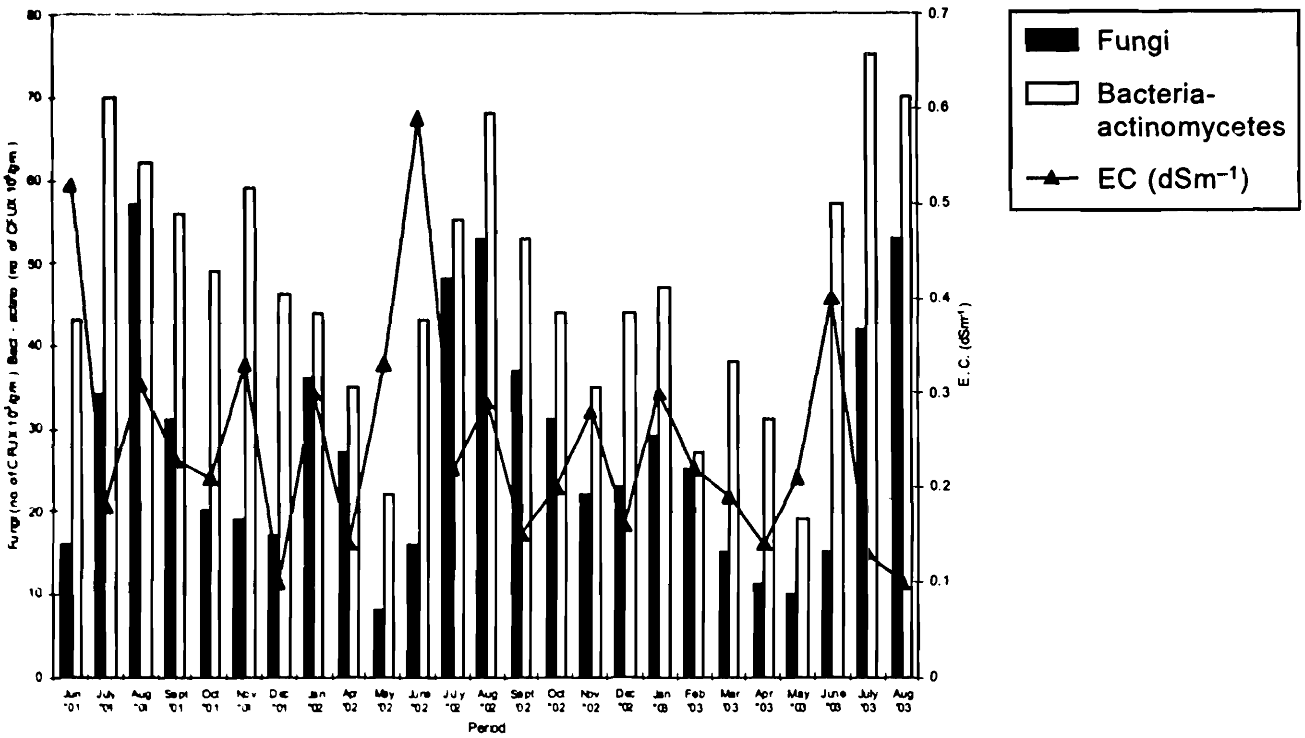


Fig. 76 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and electrical conductivity at Site III (BRF)

Fluctuations of fungi, bacteria-actinomycetes population and organic carbon

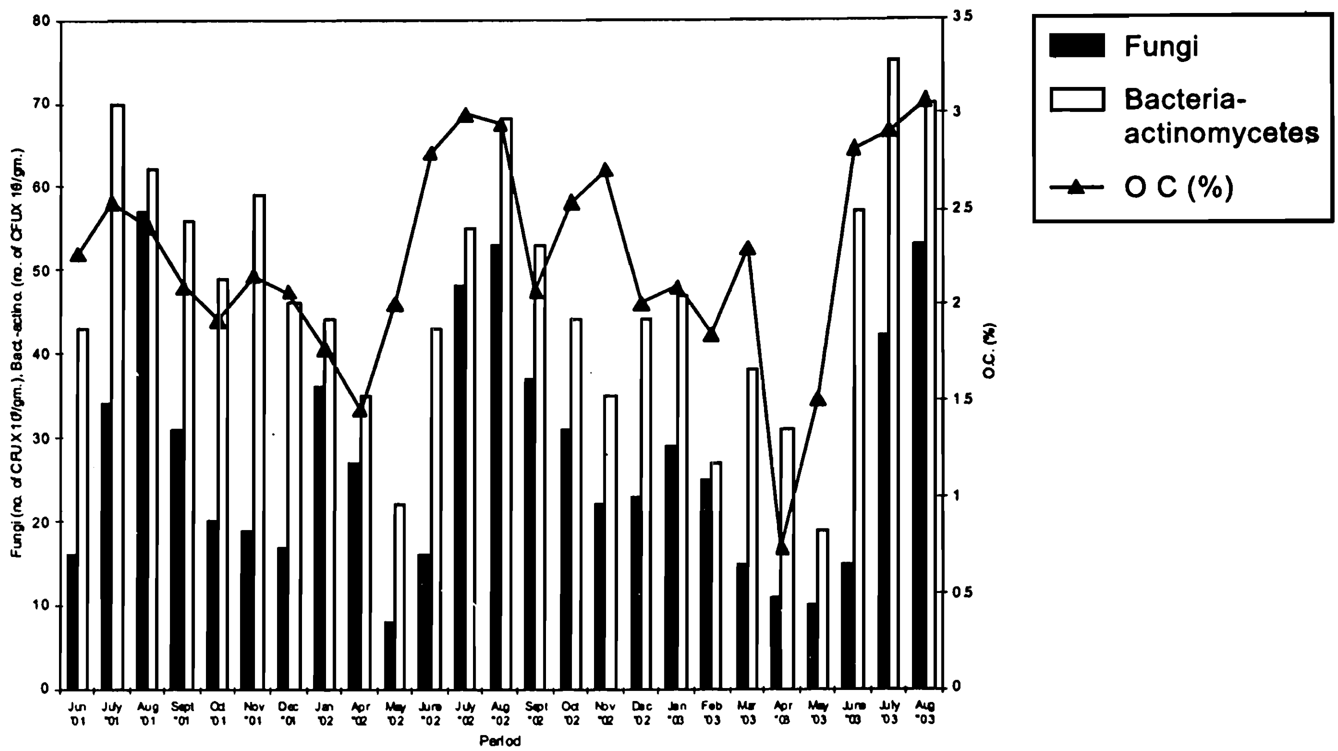


Fig. 77 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and organic Carbon at Site III (BRF)

Fluctuations of fungi, bacteria-actinomycetes population and available N_2

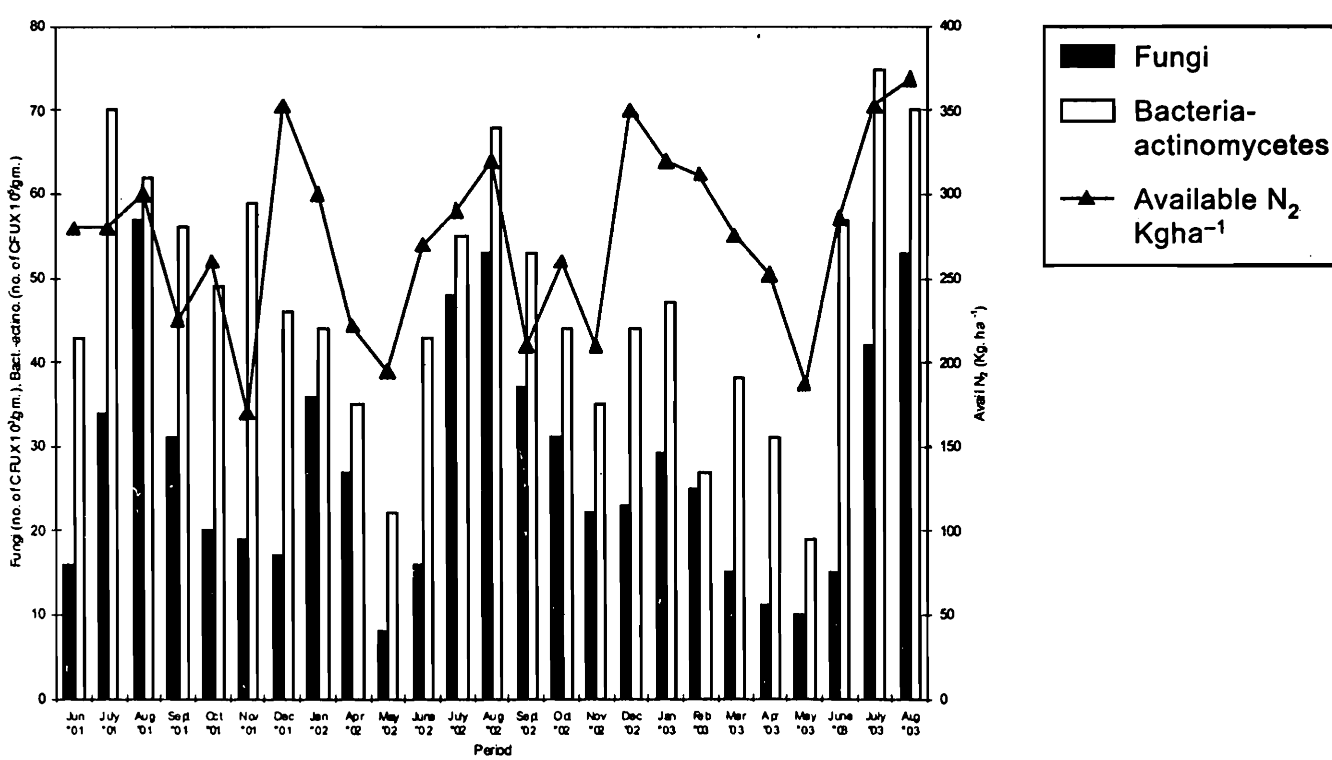


Fig. 78 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and available Nitrogen at Site III (BRF)

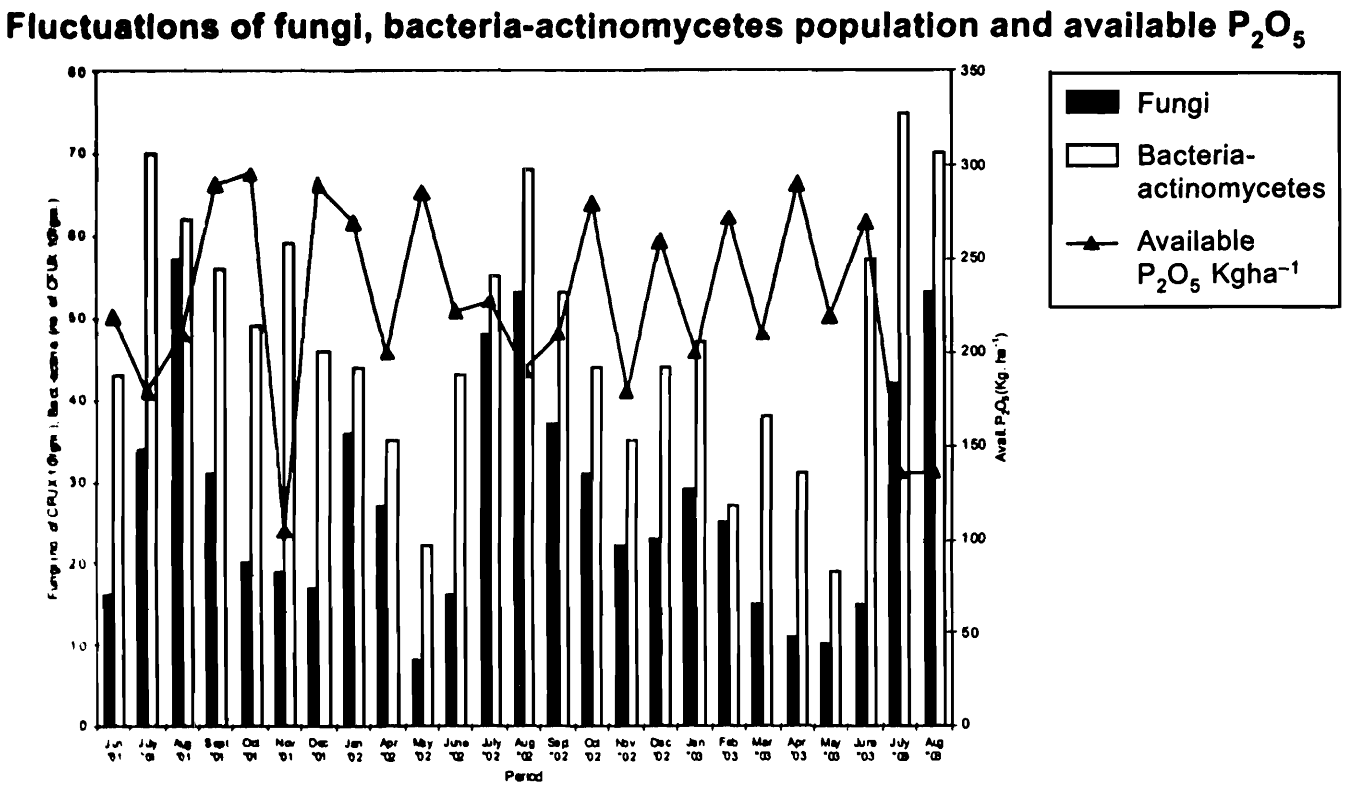


Fig. 79 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and available P_2O_5 at Site III (BRF)

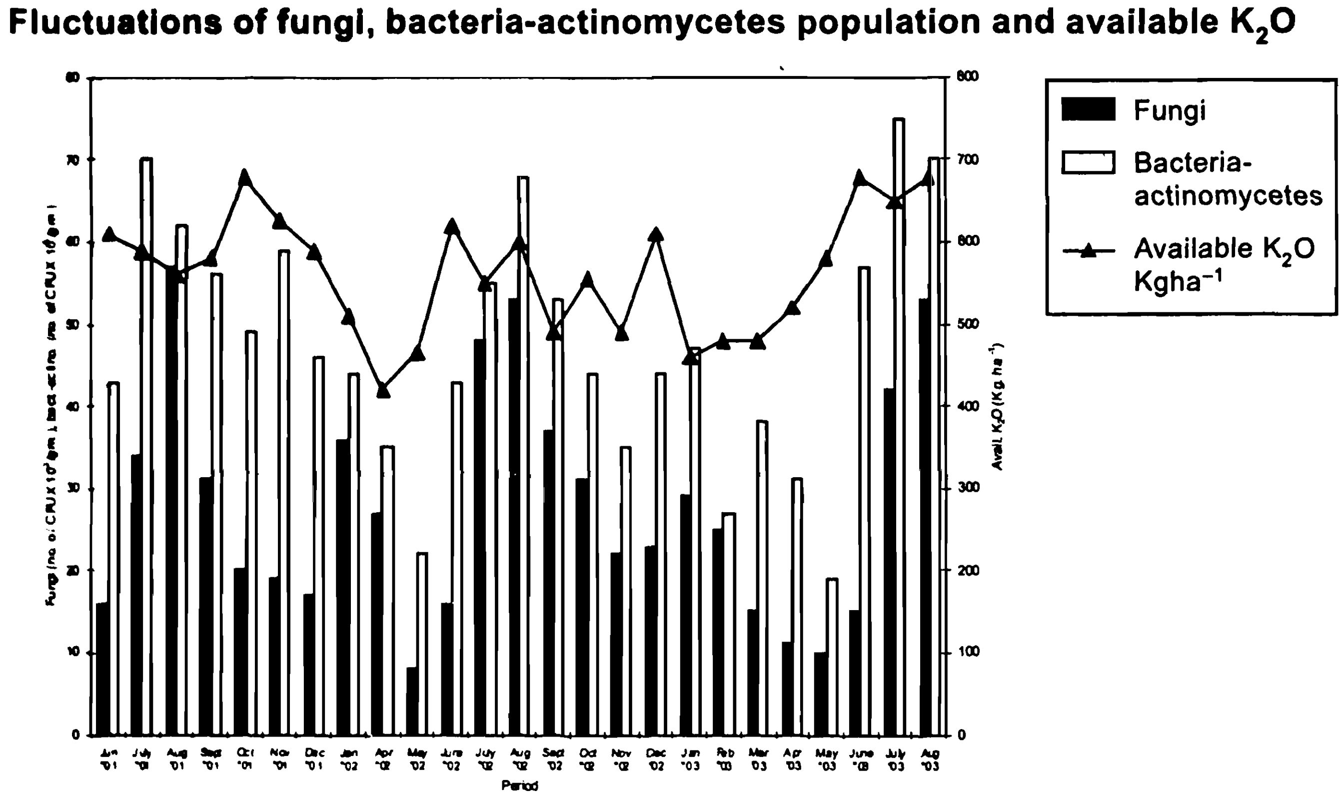


Fig. 80 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and available K_2O at Site III (BRF)

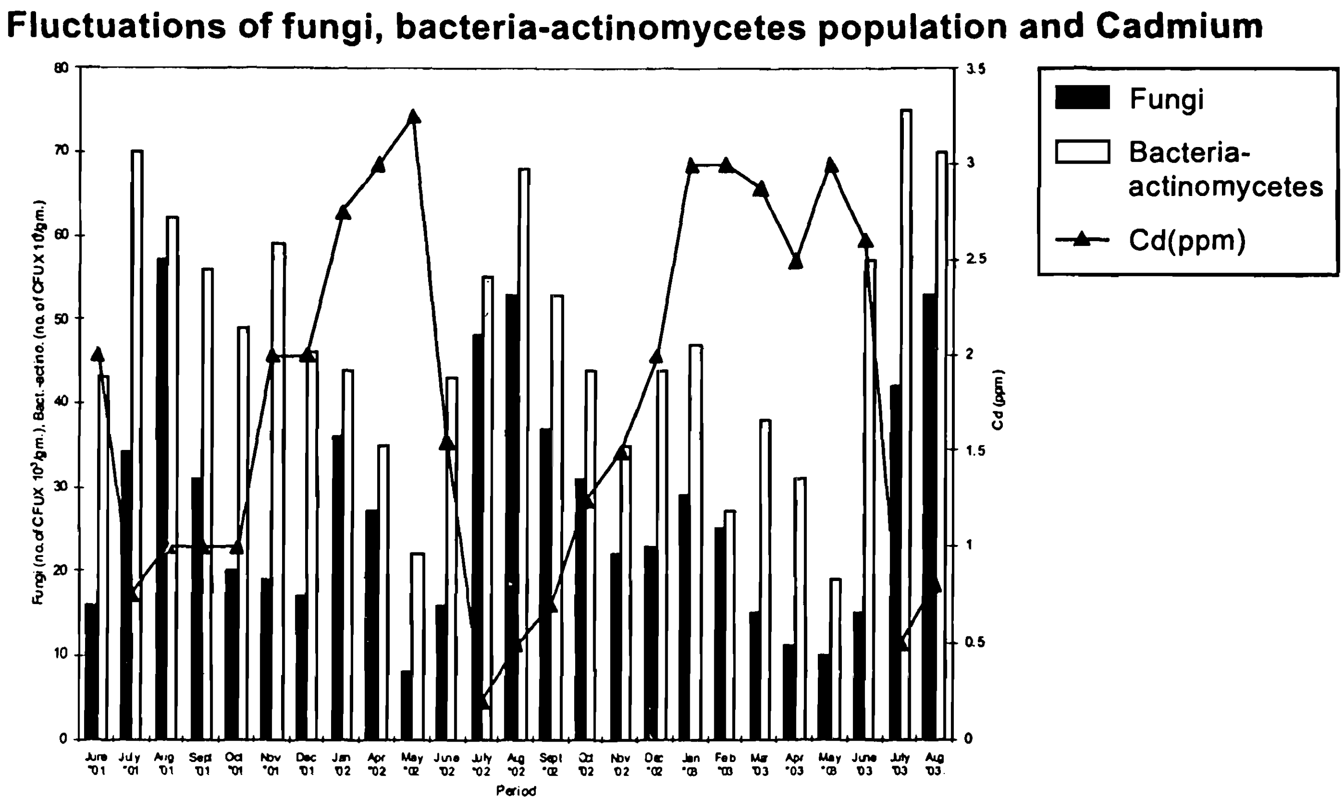


Fig. 81 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Cadmium at Site III (BRF)

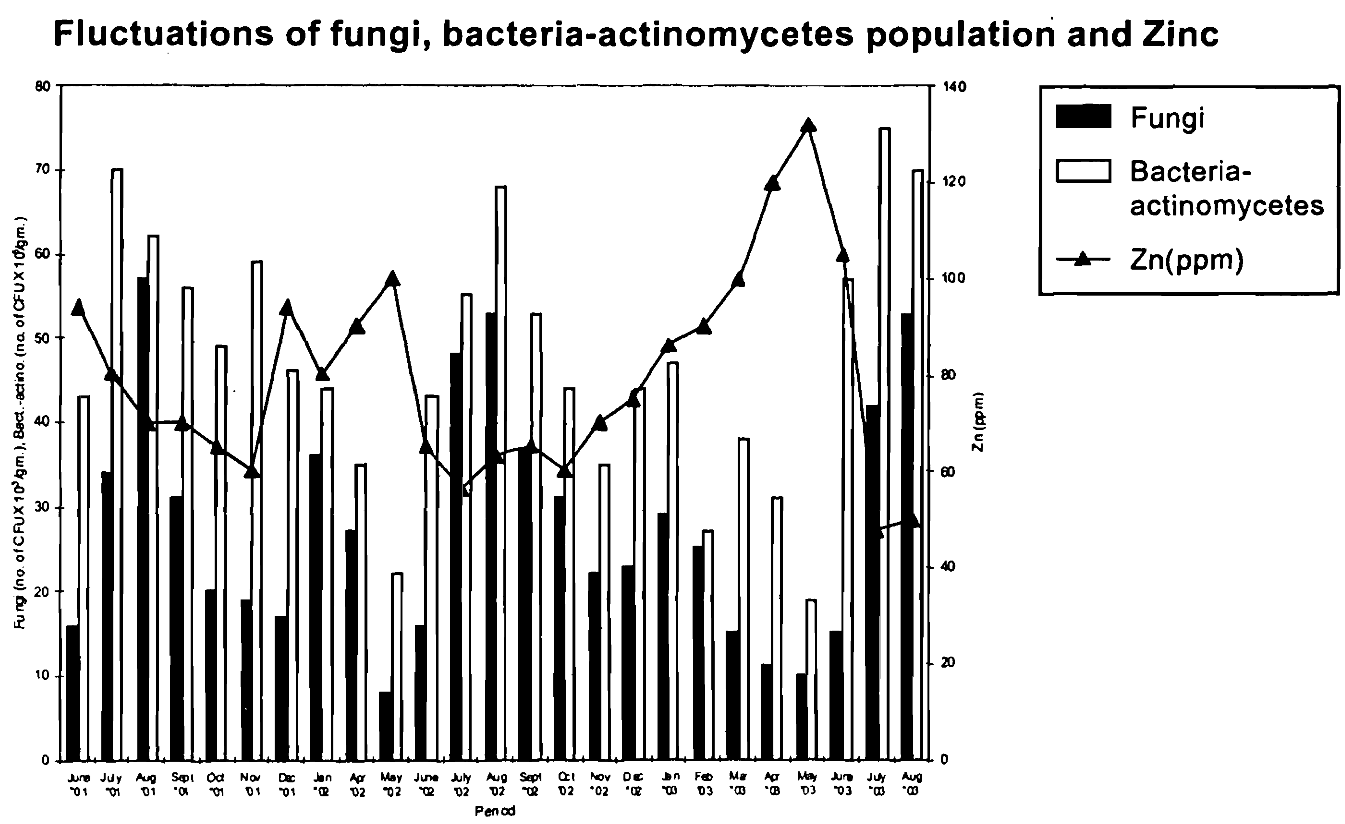


Fig. 82 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Zinc at Site III (BRF)

Fluctuations of fungi, bacteria-actinomycetes population and Lead

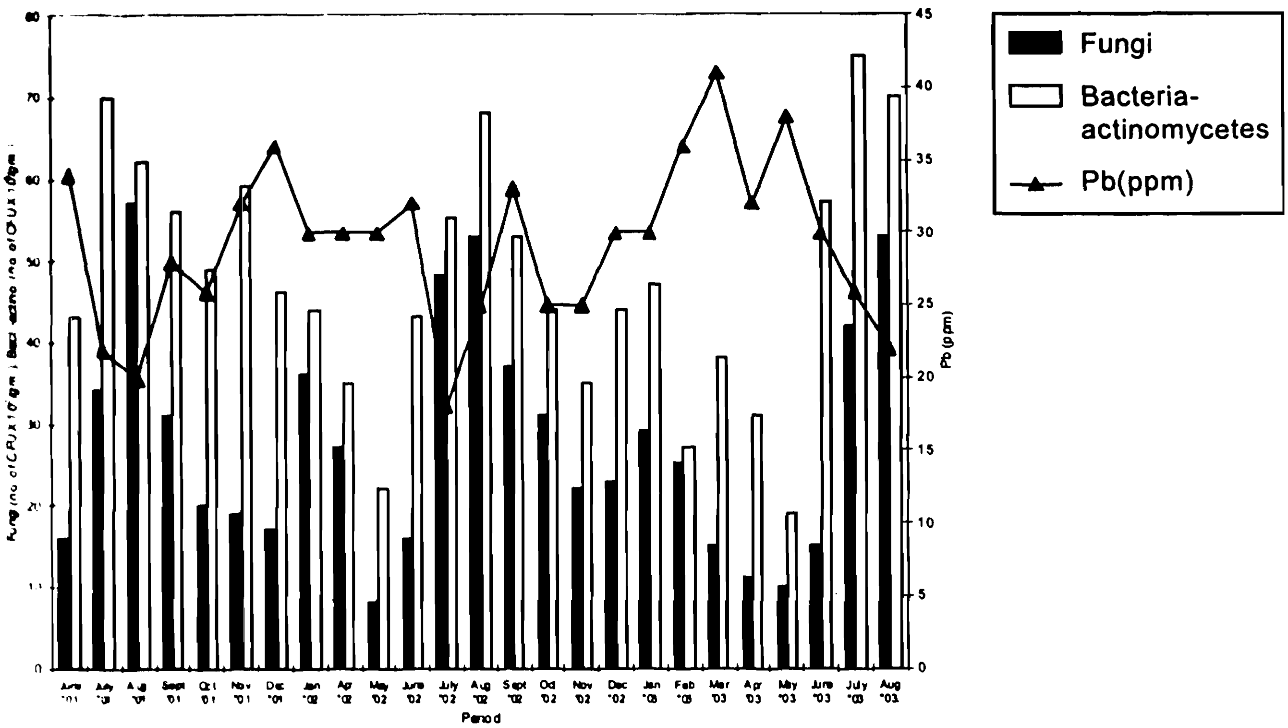


Fig. 83 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Lead at Site III (BRF)

Fluctuations of fungi, bacteria-actinomycetes population and Copper

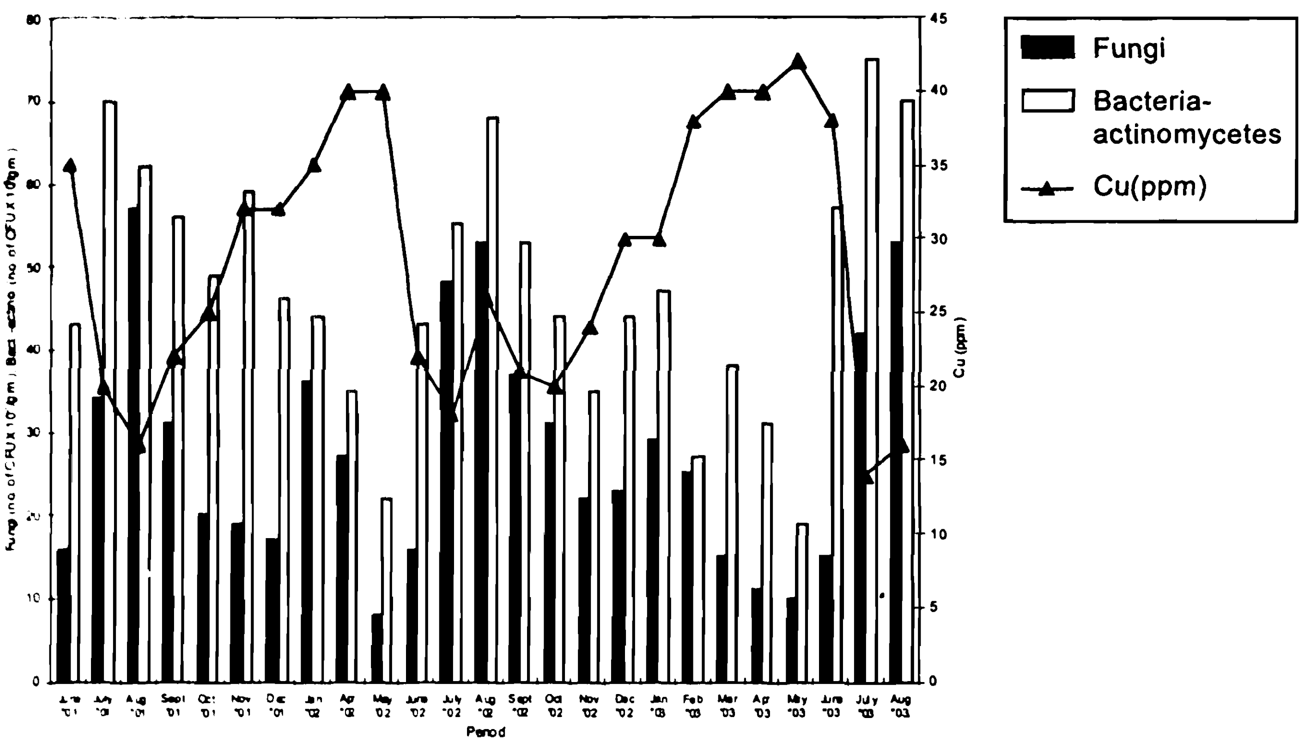


Fig. 84 : Showing monthly fluctuations of Fungi, Bacteria-actinomycetes population and Copper at Site III (BRF)

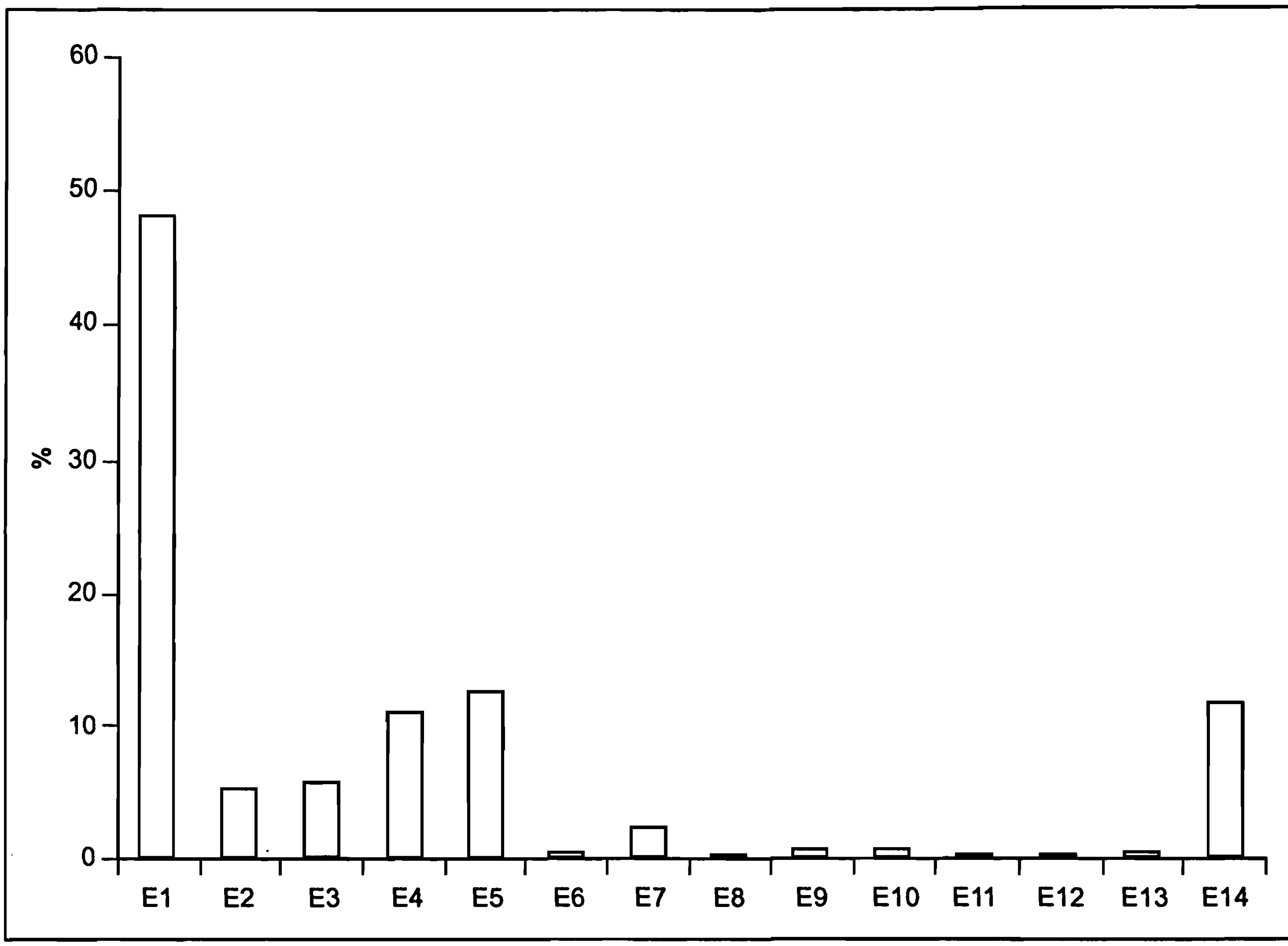


Fig. 85 : Showing abundance of different earthworm species obtained

Explanation : *E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E6 = Eutyphoeus nicholsoni; E7 = Drawida nepalensis; E8 = Perionyx simlaensis; E9 = Polypheretima elongata; E10 = Metaphire houlleti; E11 = Amynthas corticis; E12 = Octochaetona beatrix; E13 = Octochaetona surensis; E14 = Drawida papillifer papillifer*

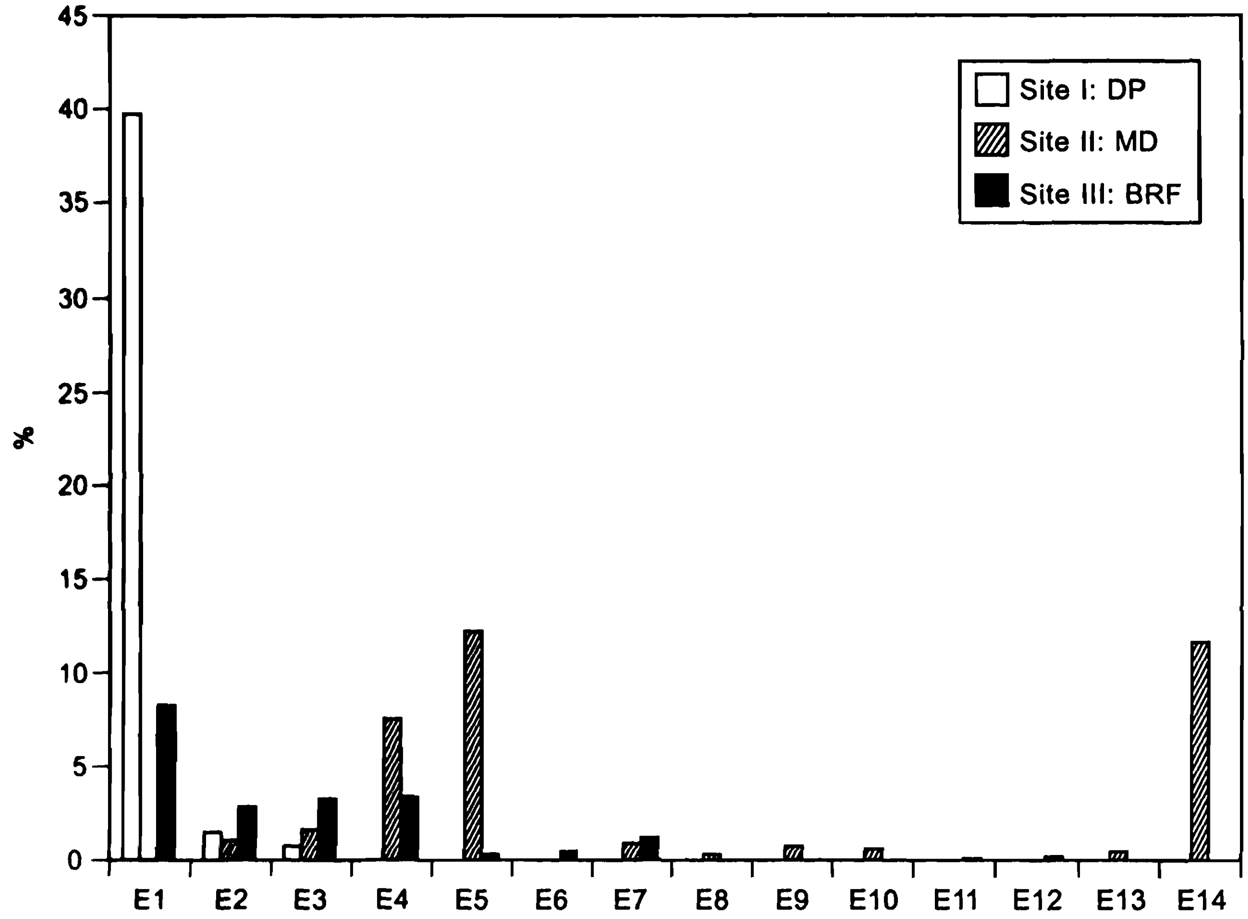


Fig. 86 : Showing relative abundance of individual earthworm species in different sampling sites

Explanation : *E1 = Lampito mauritii; E2 = Metaphire posthuma; E3 = Perionyx excavatus; E4 = Eutyphoeus orientalis; E5 = Eutyphoeus incommodus; E6 = Eutyphoeus nicholsoni; E7 = Drawida nepalensis; E8 = Perionyx simlaensis; E9 = Polypheretima elongata; E10 = Metaphire houlleti; E11 = Amynthas corticis; E12 = Octochaetona beatrix; E13 = Octochaetona surensis; E14 = Drawida papillifer papillifer*

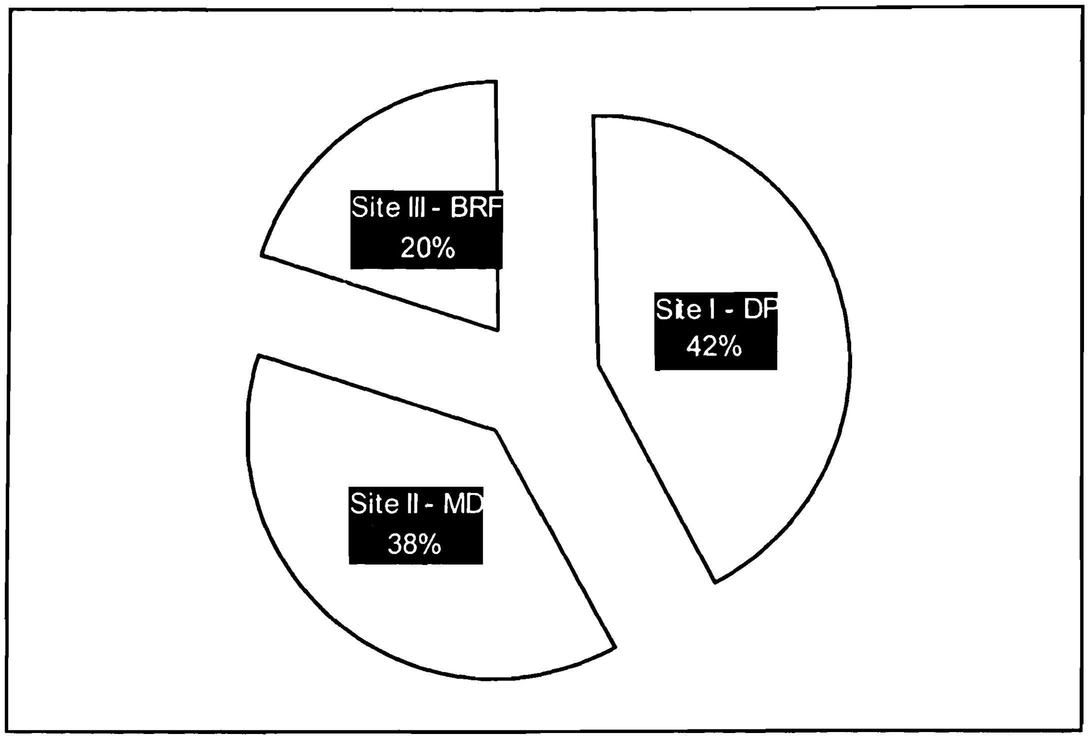


Fig. 87 : Showing site wise abundance of total population of earthworm

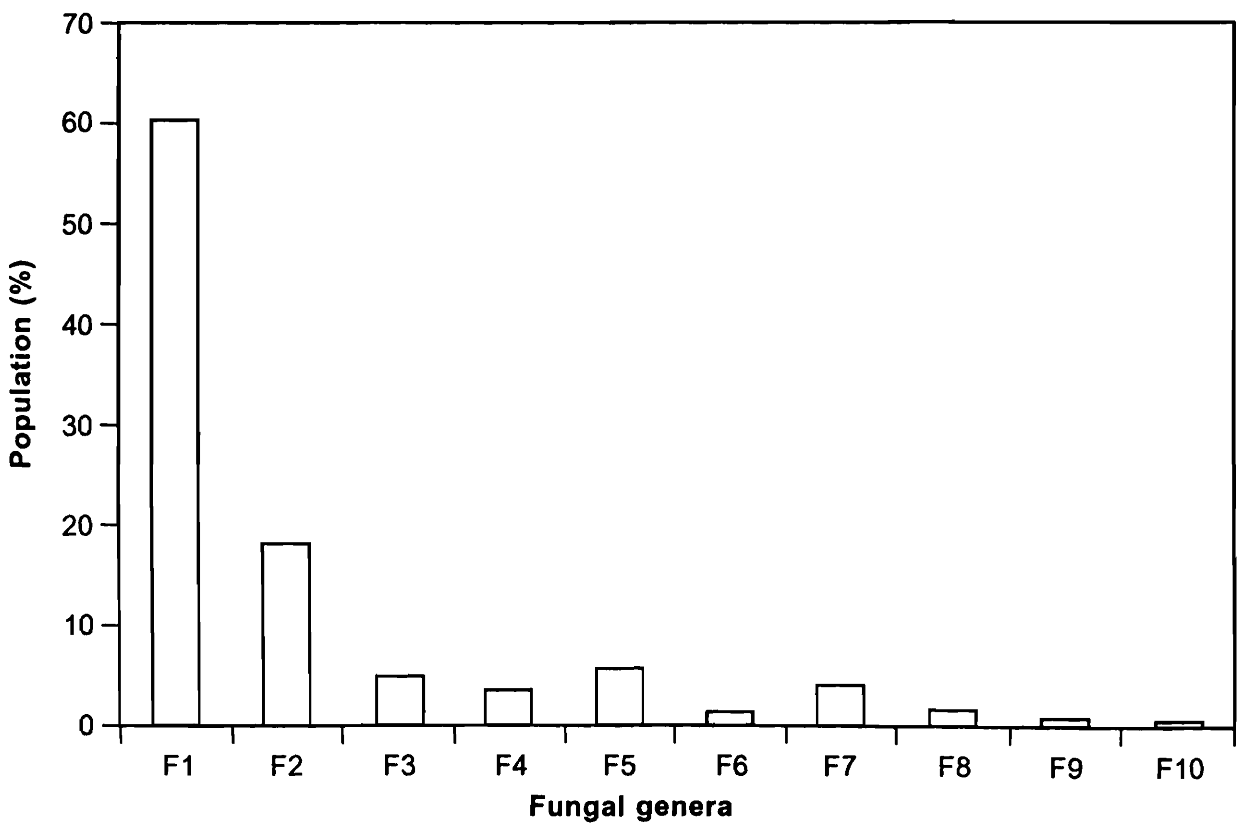


Fig. 88 : Showing abundance of different fungal genera obtained

Explanation : *F1 = Penicillium, F2 = Aspergillus, F3 = Fusarium, F4 = Trichoderma, F5 = Rhizopus, F6 = Cephalosporium, F7 = Mucor, F8 = Cladosporium, F9 = Sclerotium, F10 = Curvularia*

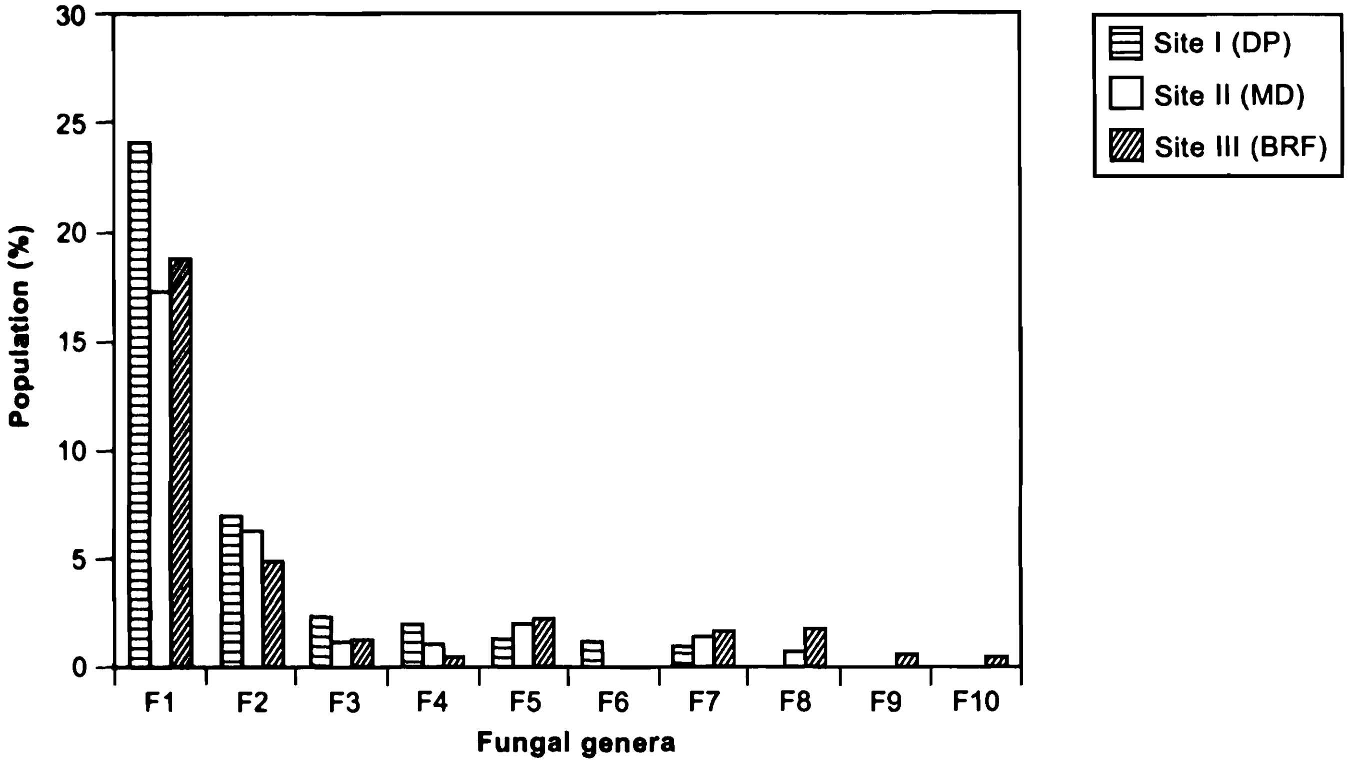


Fig. 89 : Showing relative abundance of individual fungal genera in different sampling sites

Explanation : *F1 = Penicillium, F2 = Aspergillus, F3 = Fusarium, F4 = Trichoderma, F5 = Rhizopus, F6 = Cephalosporium, F7 = Mucor, F8 = Cladosporium, F9 = Sclerotium, F10 = Curvularia*

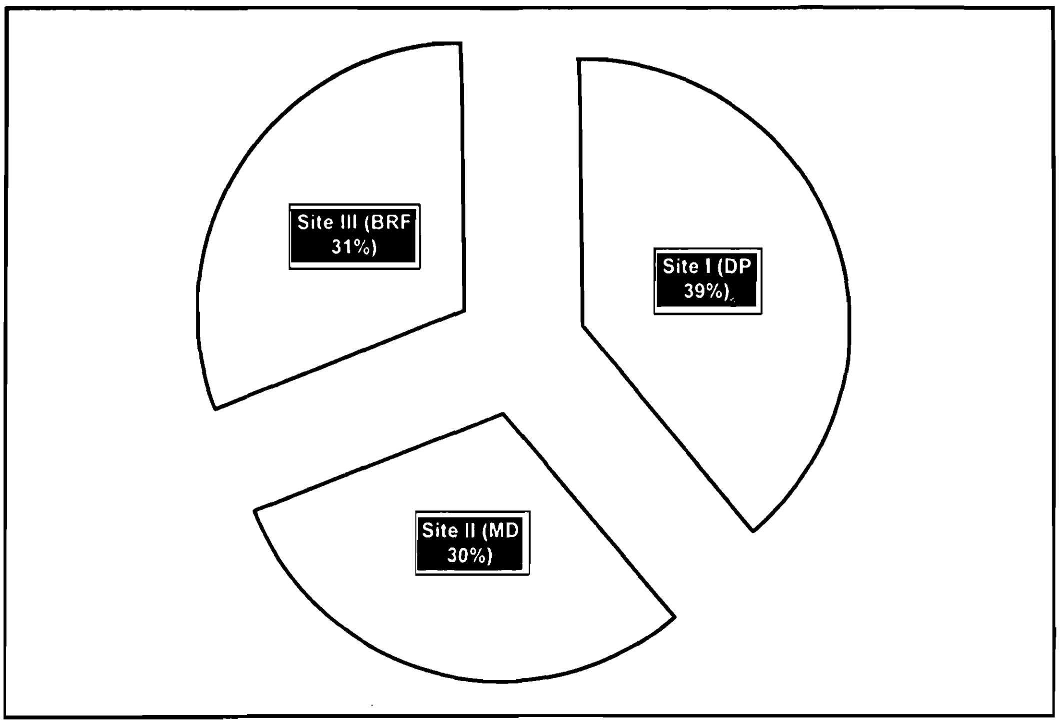


Fig. 90 : Showing site wise abundance of total population of fungal genera

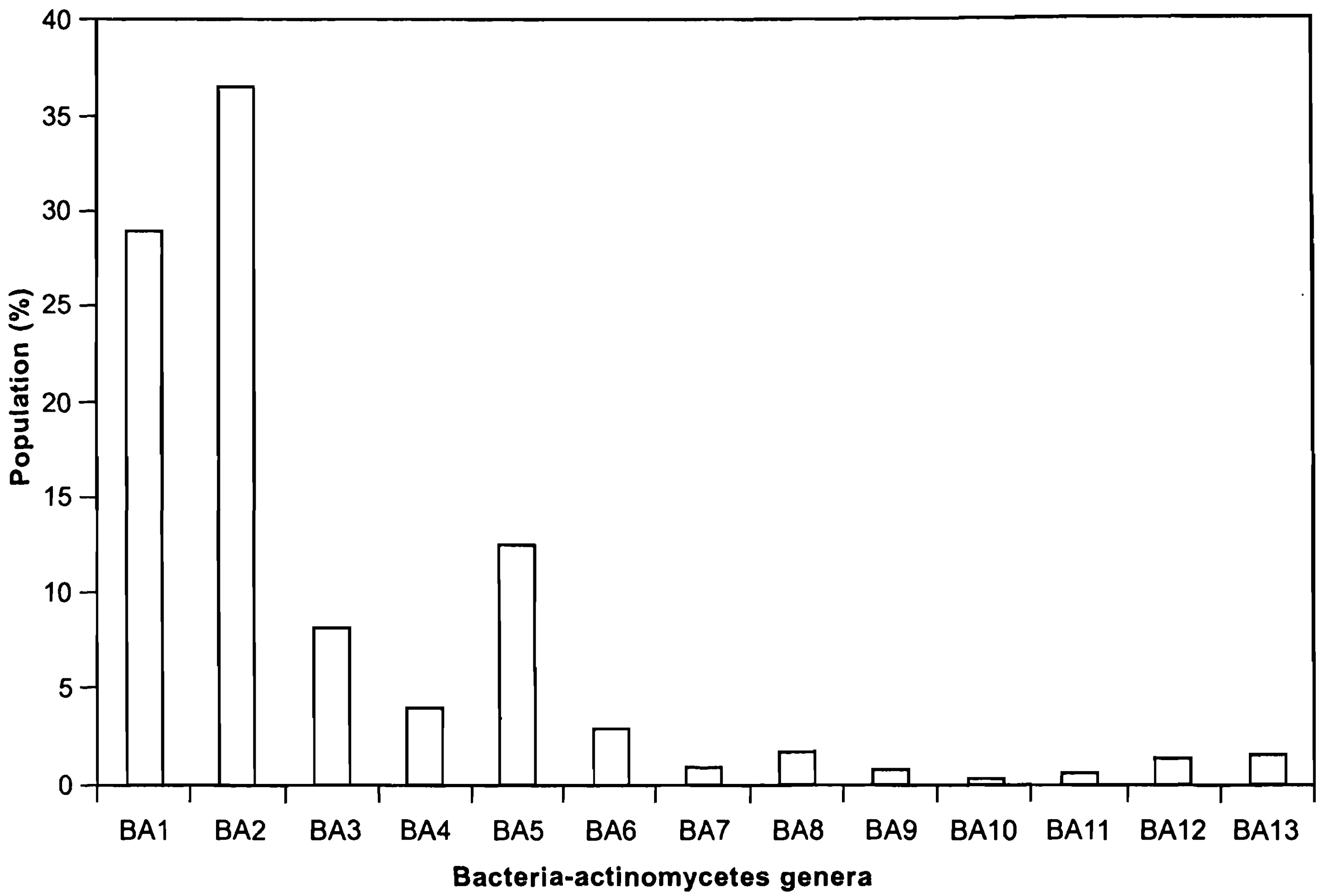


Fig. 91 : Showing abundance of different bacteria-actinomycetes genera obtained

Explanation : *BA1 = Bacillus, BA2 = Streptomyces, BA3 = Micrococcus I, BA4 = Micrococcus II, BA5 = Arthrobacter, BA6 = Pseudomonas, BA7 = Promicromonospora, BA8 = Cytophaga, BA9 = E. coli, BA10 = Flavobacterium, BA11 = Enterobacter, BA12 = Azotobacter, BA13 = Nocardia*

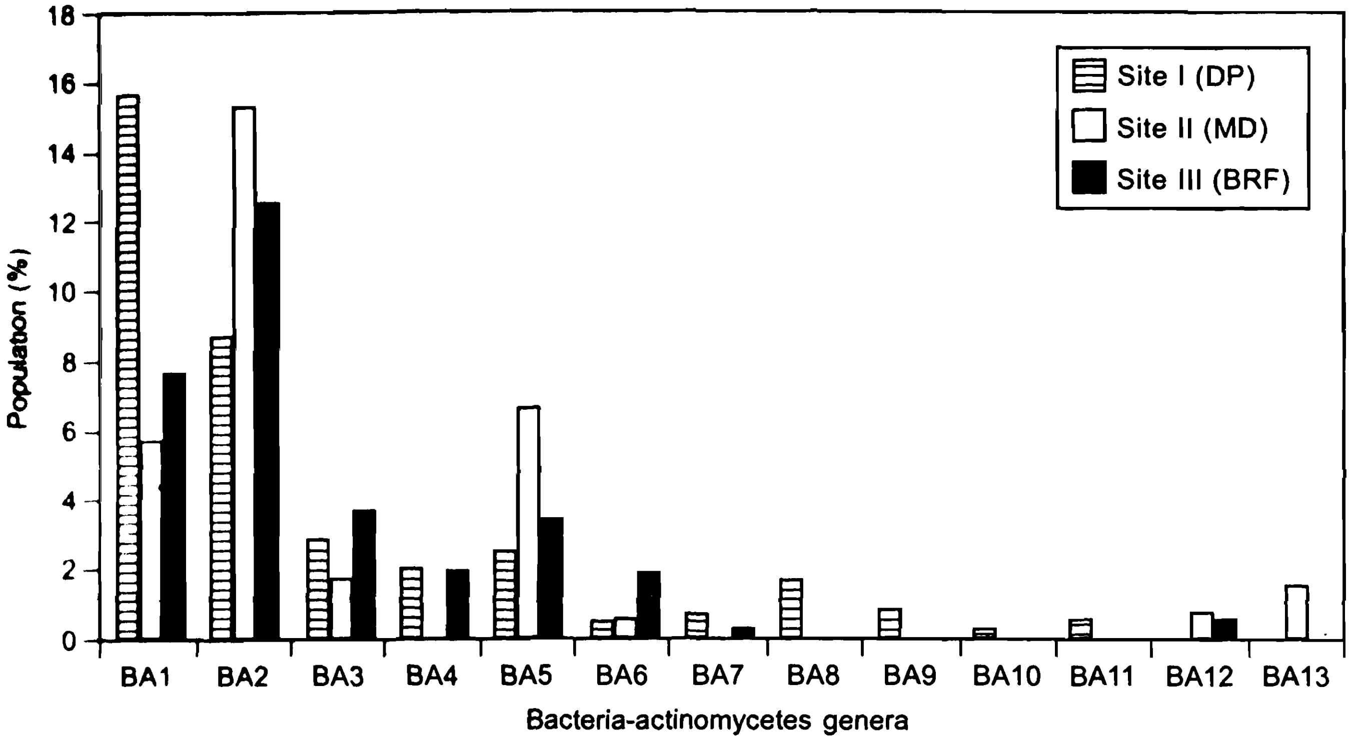


Fig. 92 : Showing relative abundance of individual bacteria-actinomycetes genera in different sampling sites

Explanation : *BA1 = Bacillus, BA2 = Streptomyces, BA3 = Micrococcus I, BA4 = Micrococcus II, BA5 = Arthrobacter, BA6 = Pseudomonas, BA7 = Promicromonospora, BA8 = Cytophaga, BA9 = E. coli, BA10 = Flavobacterium, BA11 = Enterobacter, BA12 = Azotobacter, BA13 = Nocardia*

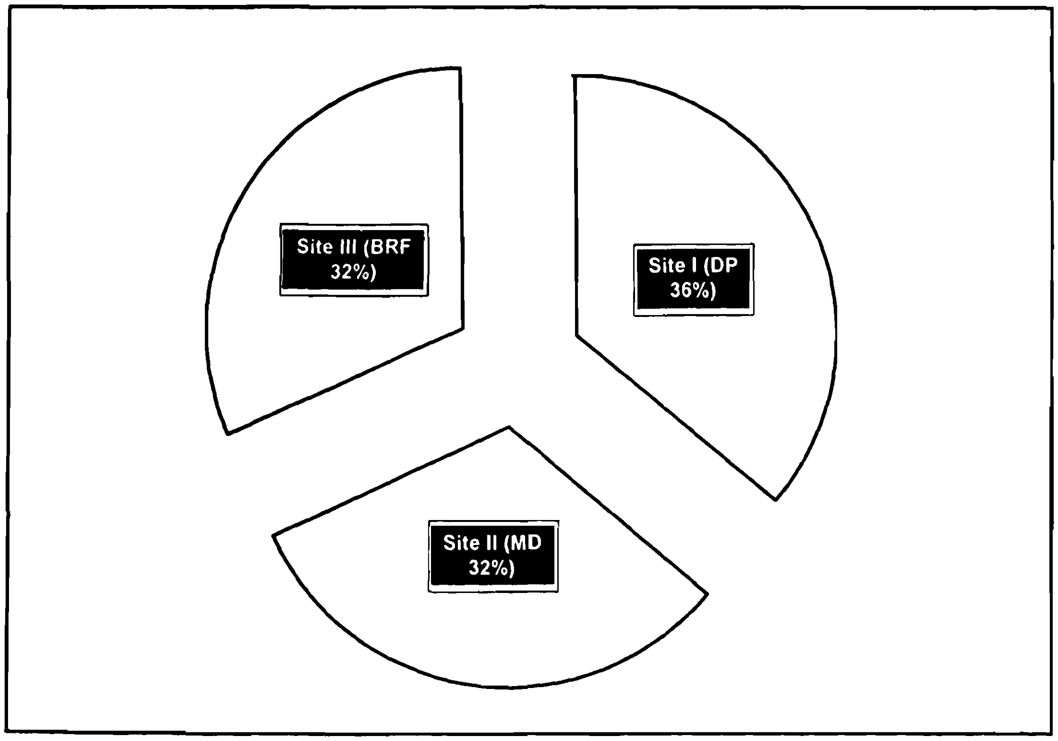


Fig. 93 : Showing site wise abundance of total population of bacteria-actinomycetes genera

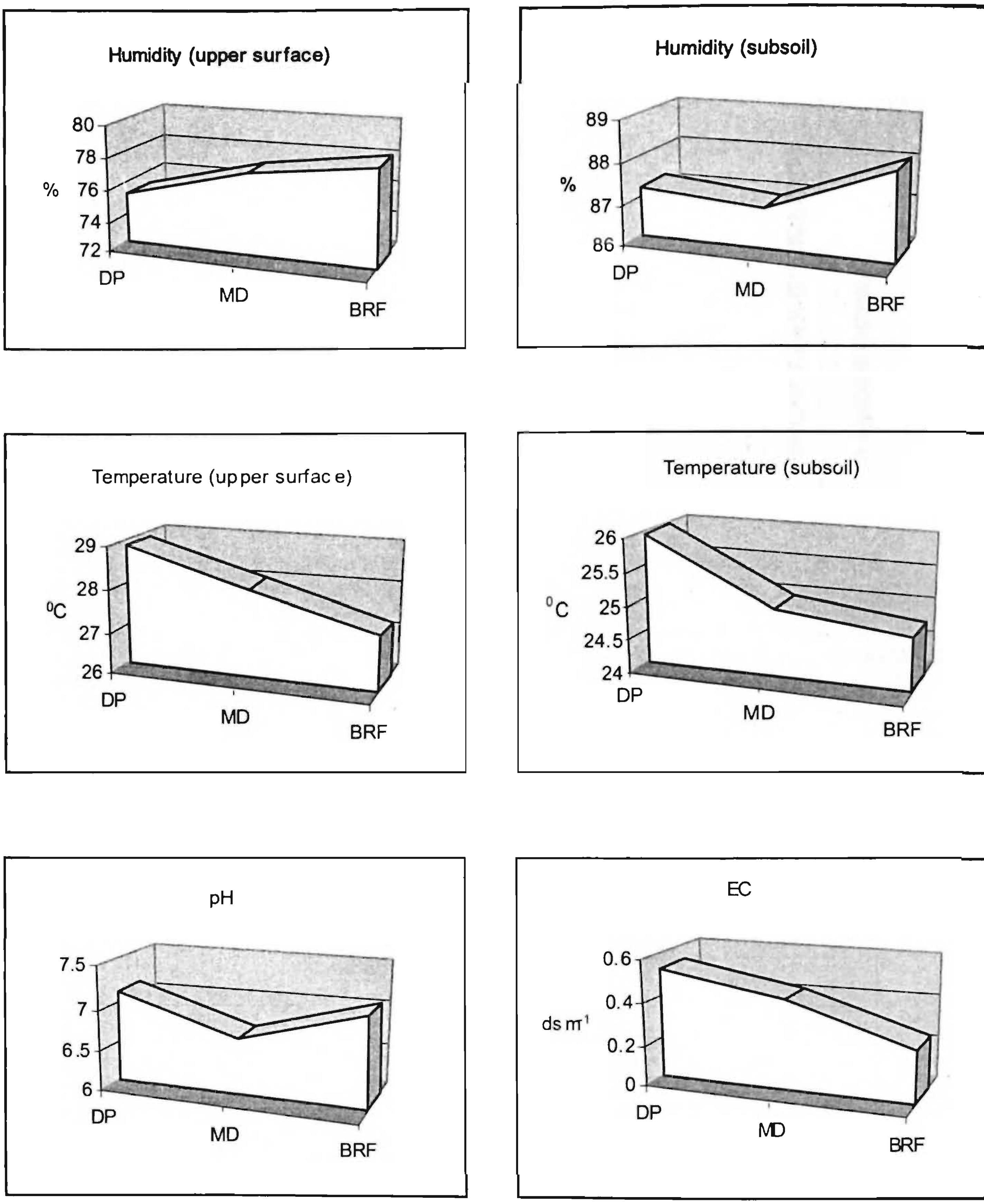


Fig. 94 : Mean values of edaphic factors in the studied sites

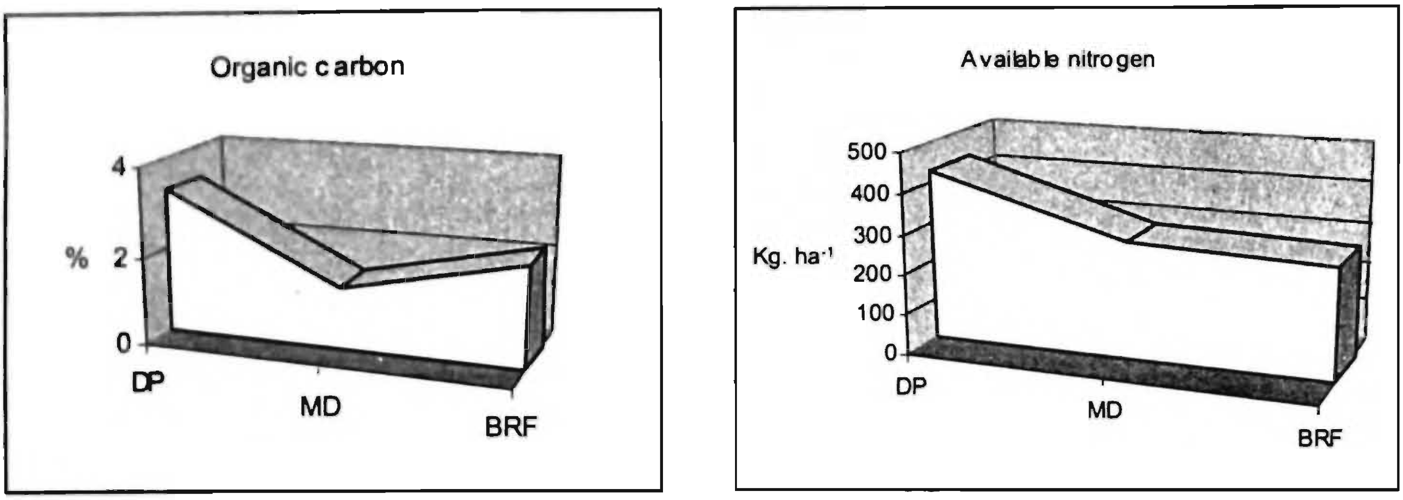


Fig. 94 (Contd.) : Mean values of edaphic factors in the studied sites

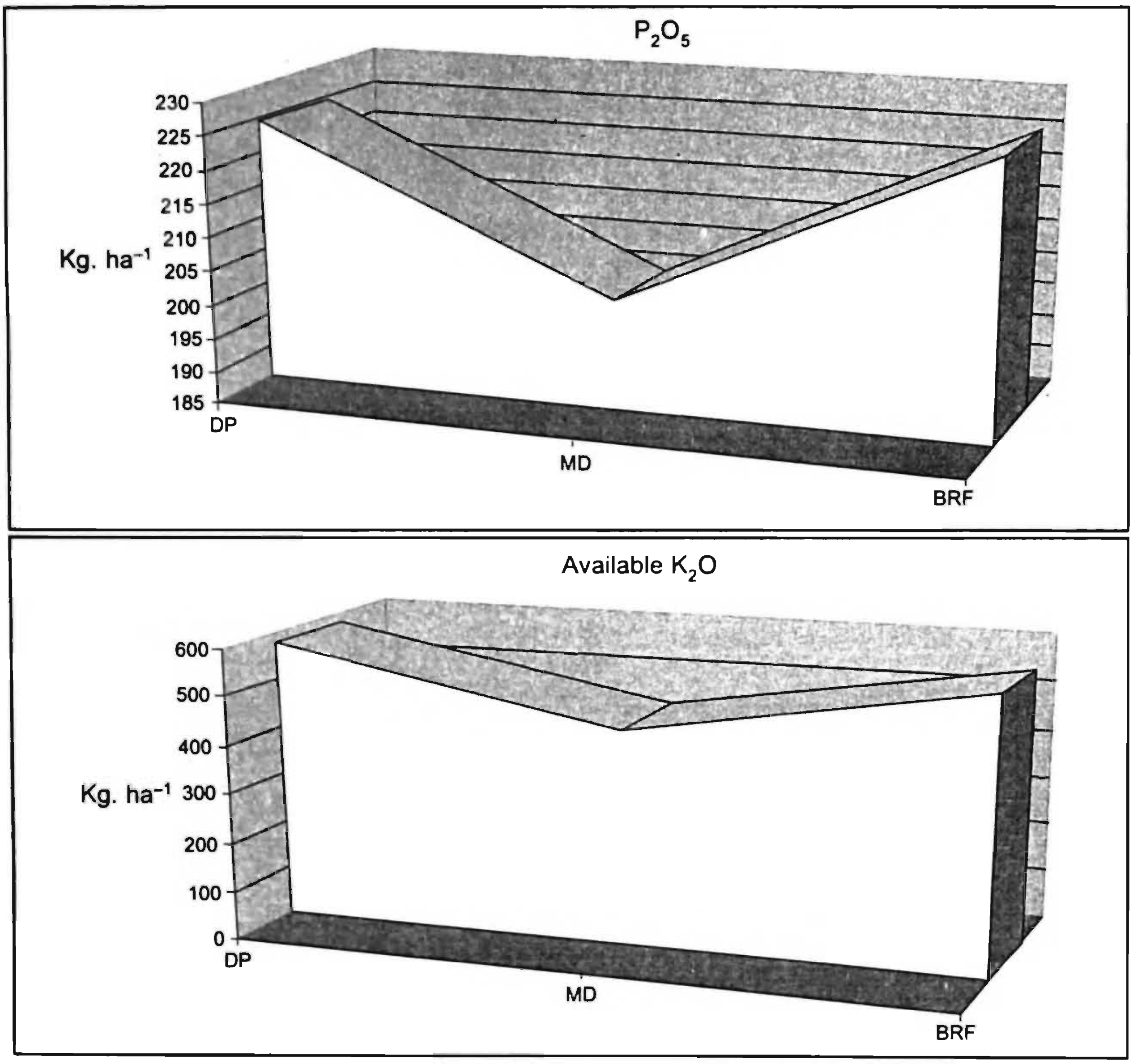
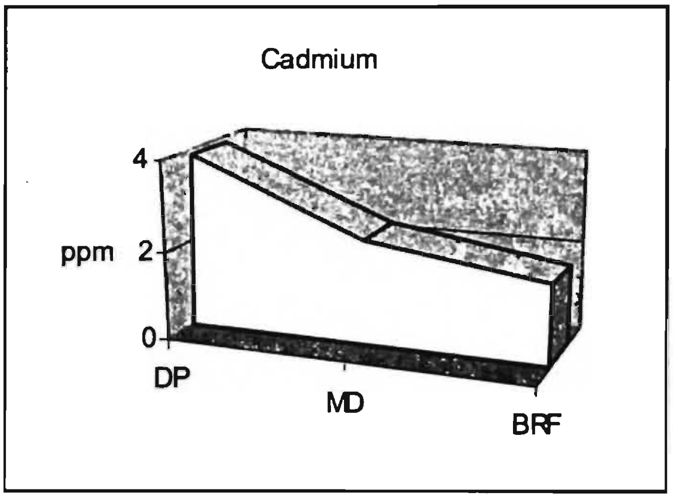


Fig. 94 (Contd.) : Mean values of edaphic factors and heavy metals in the studied sites



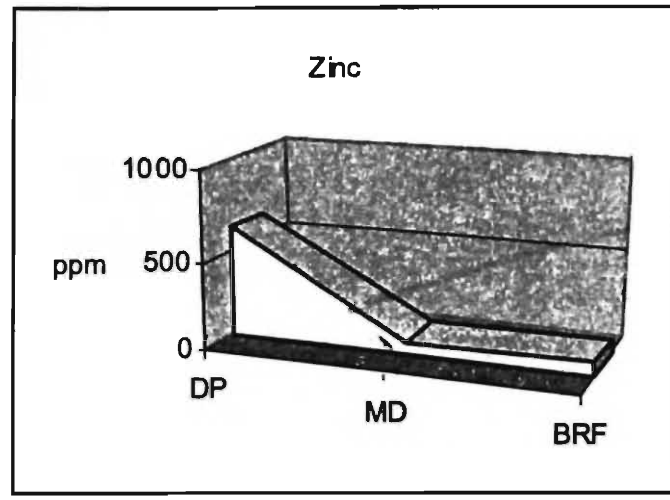
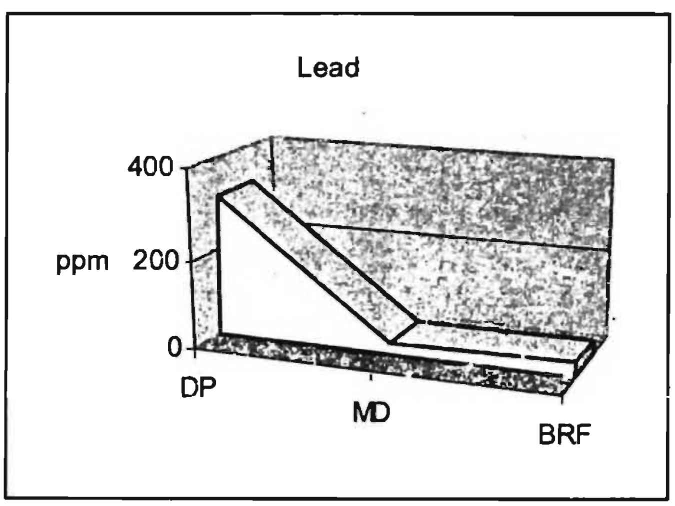


Fig. 94 (Contd.) : Mean values of edaphic factors and heavy metals in the studied sites



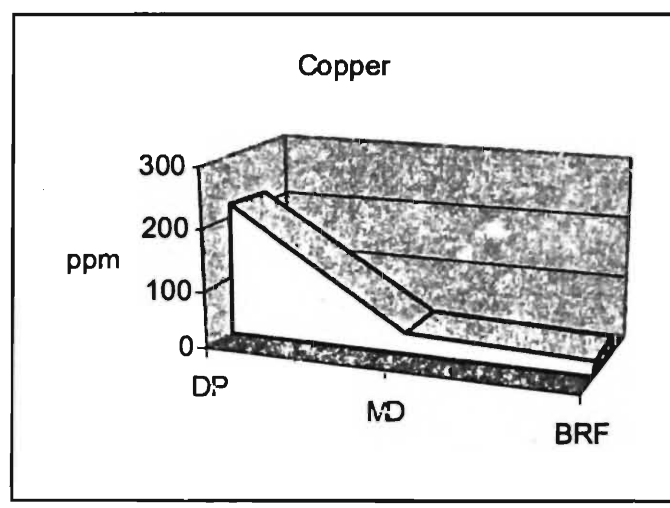


Fig. 94 (Contd.) : Mean values of heavy metals in the studied sites

Plate I : *Drawida nepalensis* Michaelsen

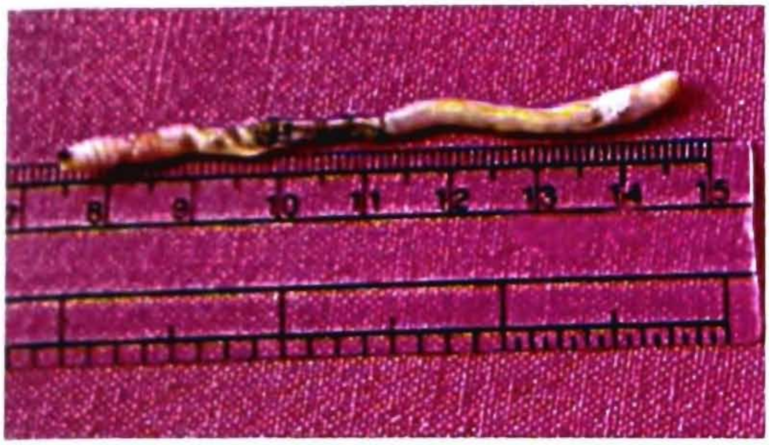


Figure a : Entire worm, ventral view

Figure b : Anterior end, ventral view showing male genital region

Plate II : *Drawida papillifer papillifer* Stephenson

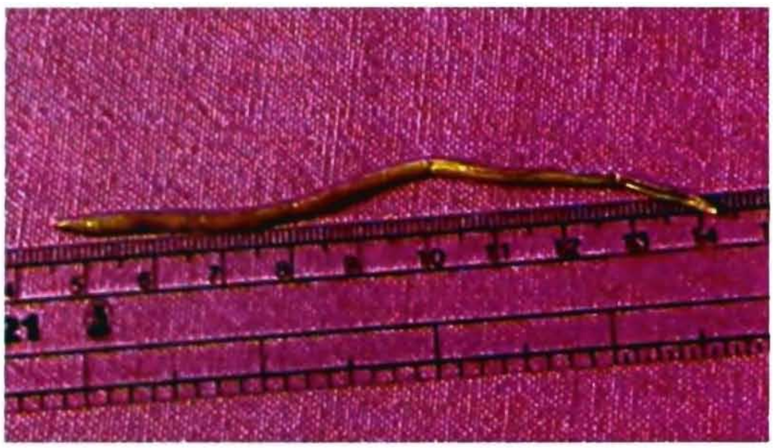


Figure a : Entire worm, ventro-lateral view

Figure b : Anterior end showing male genital region

Plate III : *Eutyphoeus incommodus* (Beddard)

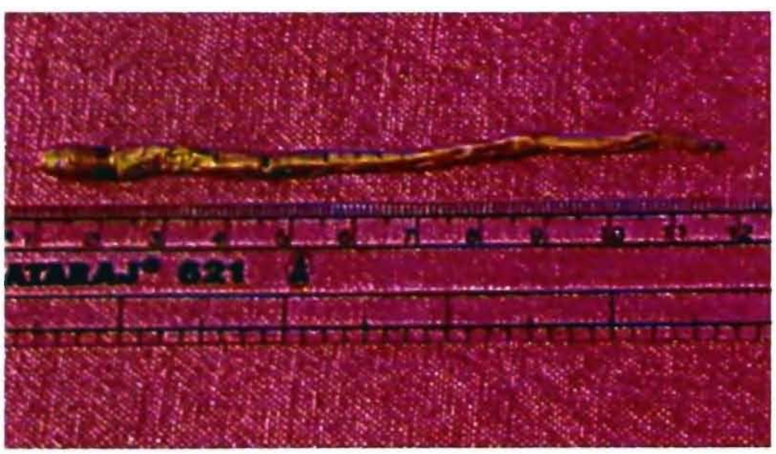


Figure a : Entire worm, ventral view

Figure b : Anterior end showing male genital region and spermathecal pore. Sp.P, spermathecal pore

Plate IV : *Eutyphoeus nicholsoni* (Beddard)

Figure a : Entire worm, ventral view

Figure b : Anterior end showing male genital and spermathecal pore region. Sp.P, spermathecal pore

Plate V : *Eutyphoeus orientalis* (Beddard)

Figure a : Entire worm, ventral view

Figure b : Anterior end, ventral view showing male genital region

Plate VI : *Octochaetona beatrix* (Beddard)

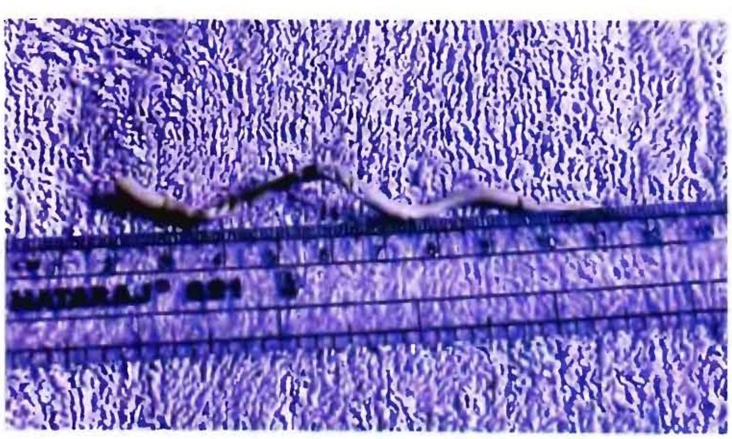


Figure a : Entire worm, ventral view

Figure b : Anterior end, ventral view showing male genital region

Plate VII : *Octochaetona surensis* (Michaelsen)

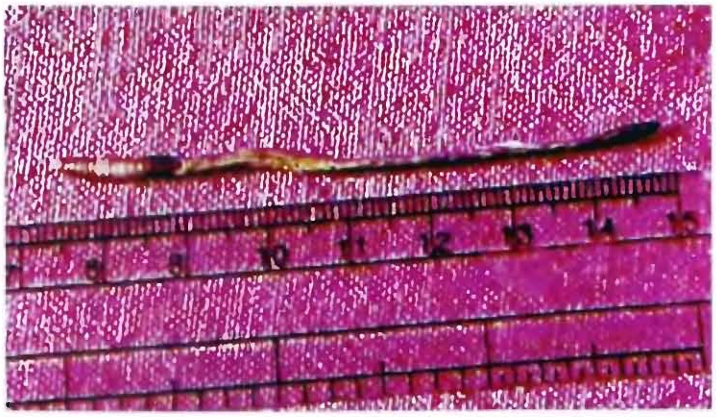


Figure a : Entire worm, ventral view

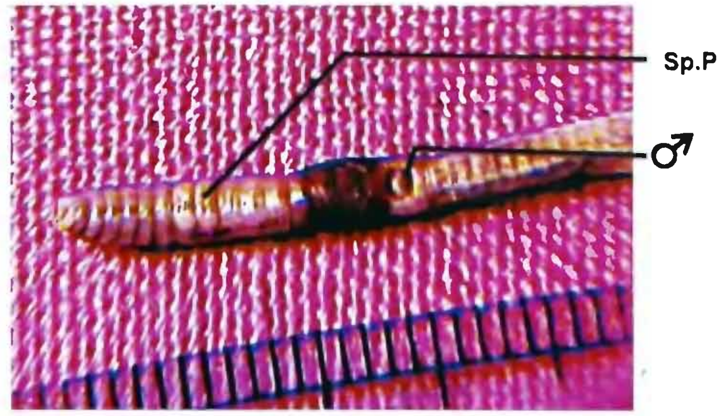


Figure b : Anterior end, ventral view showing male genital and spermathecal pore region. Sp.P, spermathecal pore

Plate VIII : *Lampito mauritii* Kinberg

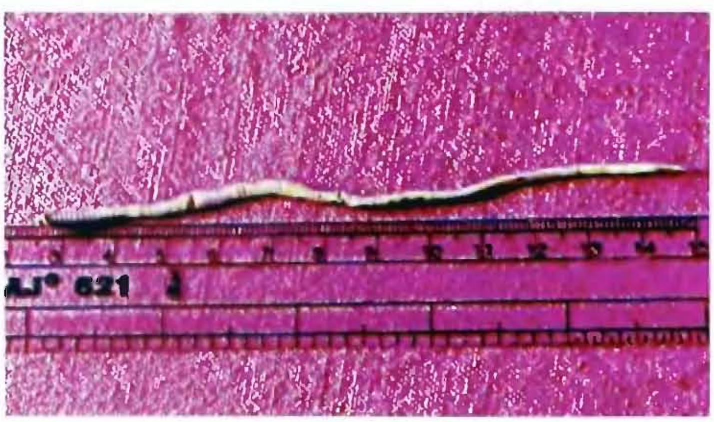


Figure a : Entire worm, ventral view

Figure b : Anterior end, ventral view showing male genital region. Ps, penial setae

Plate IX : *Metaphire posthuma* (Vaillant)

Figure a : Entire worm, ventral view

Figure b : Anterior end, ventral view showing male genital region. Gm, genital marking

Plate X : *Metaphire houlleti* (Perrier)

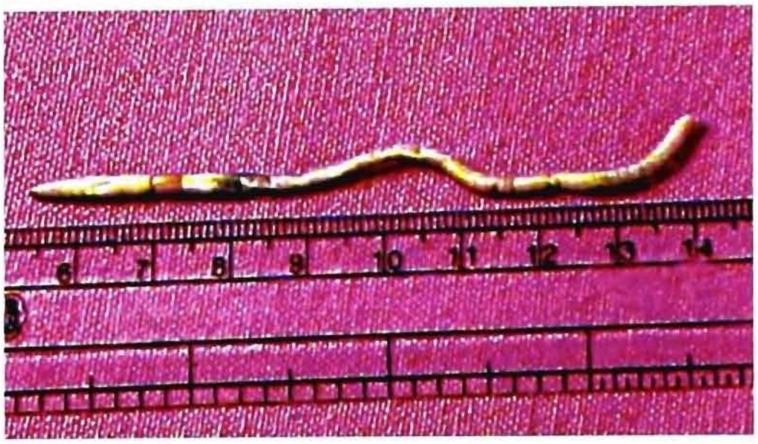


Figure a : Entire worm, ventral view

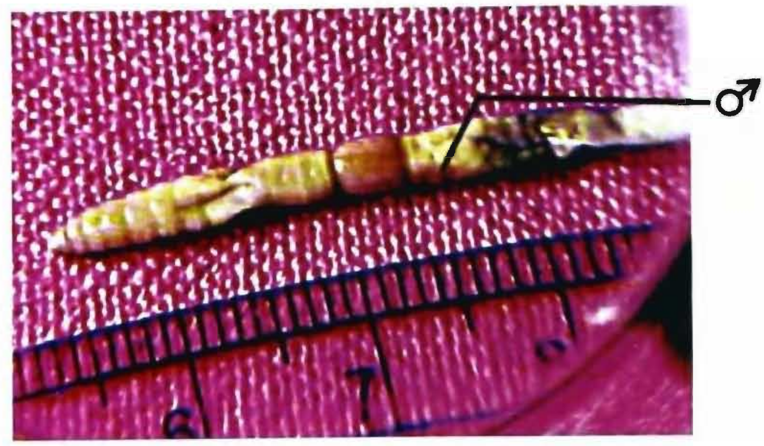


Figure b : Anterior end, ventral view showing male genital region

Plate XI : *Perionyx excavatus* Perrier

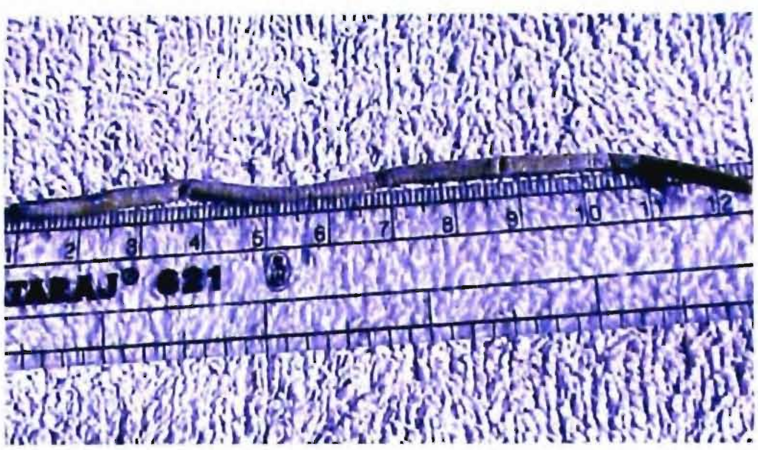


Figure a : Entire worm, ventral view

Figure b : Anterior end, ventral view showing male genital region

Plate XII : *Perionyx simlaensis* (Michaelsen)

Figure a : Entire worm, ventral view

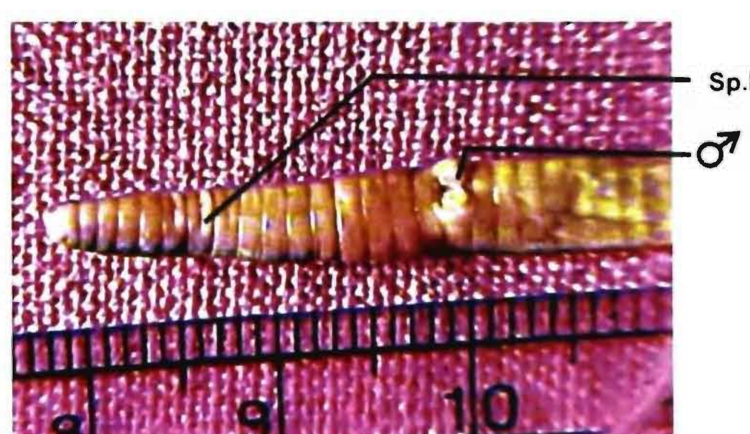


Figure b : Anterior end, ventral view showing male genital and spermathecal pore region. Sp.P, spermathecal pore

Plate XIII : *Polypheretima elongata* (Perrier)

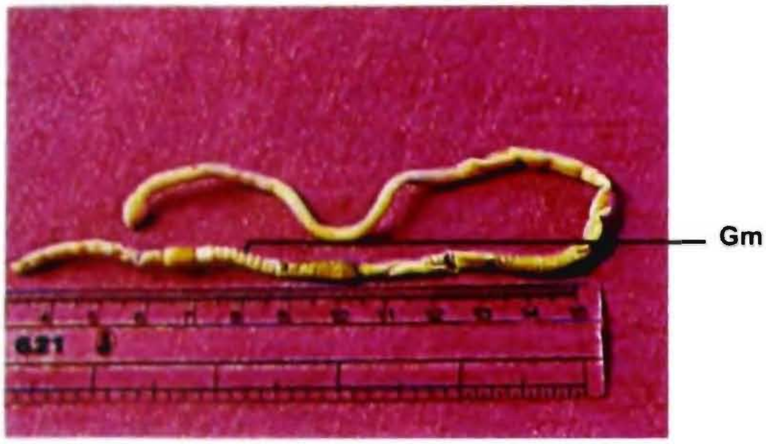


Figure a : Entire worm, ventral view. Gm, genital marking

Figure b : Anterior end, ventral view showing male genital region

Plate XIV : *Amynthas corticis* (Kinberg)

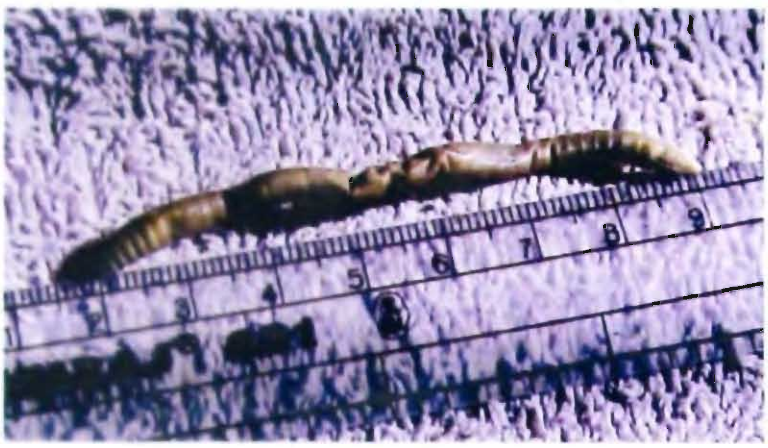


Figure a : Entire worm, ventral view

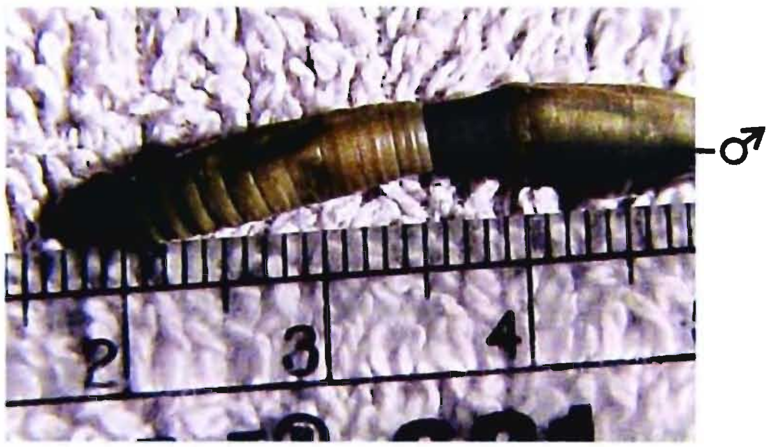


Figure b : Anterior end, ventral view showing male genital region

Plate XV

Showing sampling site at Dhapa, Municipal wastes disposal site (Site I)

Plate XVI

Showing sampling site at Madhyamgram, uncultivated field (Site II)

Plate XVII

Showing sampling site at Bethuadahari Reserve Forest (Site III)

Plate XVIII

Figure a : Showing colonies of soil microorganisms in spread plate culture

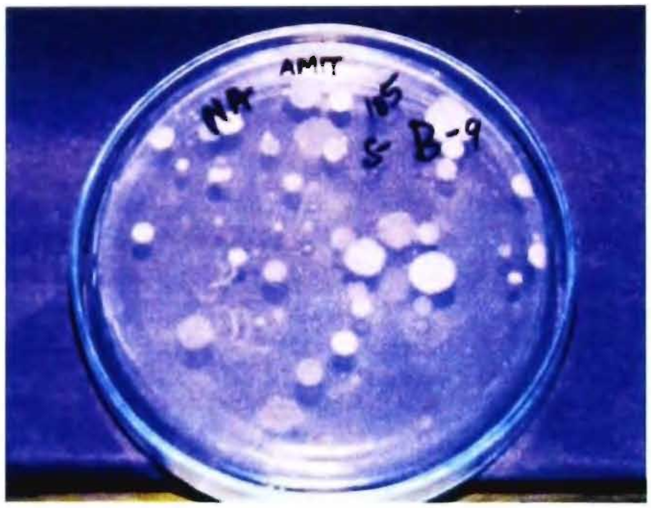


Figure b : Showing colonies of soil microorganisms in spread plate culture

Plate XIX

Figure a : Showing colonies of soil microorganisms in spread plate culture

Figure b : Showing colonies of soil microorganisms in spread plate culture

Plate XX

Figure a : Showing streak-plate culture for isolation of pure bacterial strain from soil

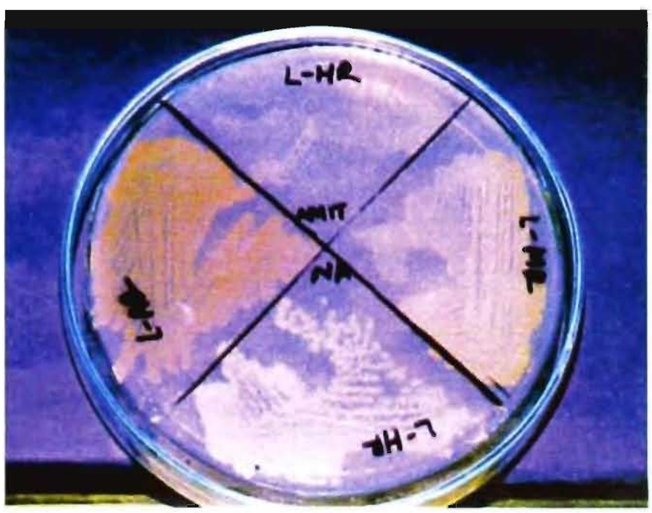


Figure b : Showing streak-plate culture for isolation of pure bacterial strain from soil

Plate XXI

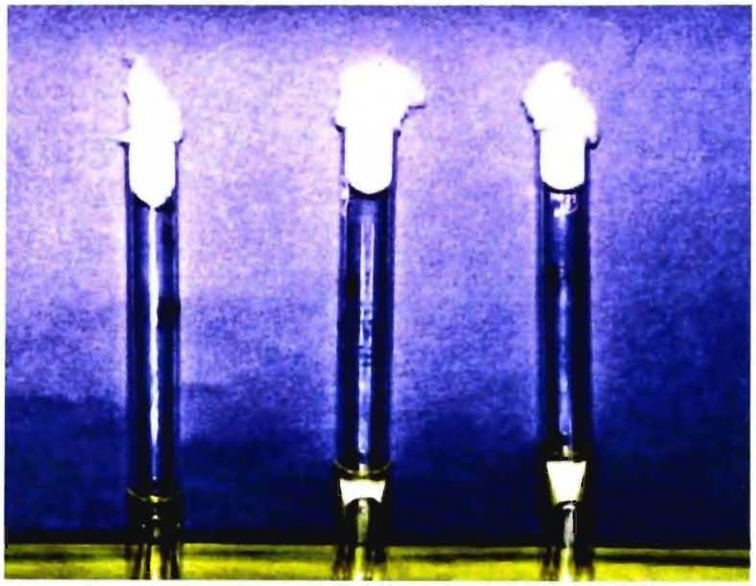


Figure a : Showing biochemical tests for isolation of pure bacterial strain

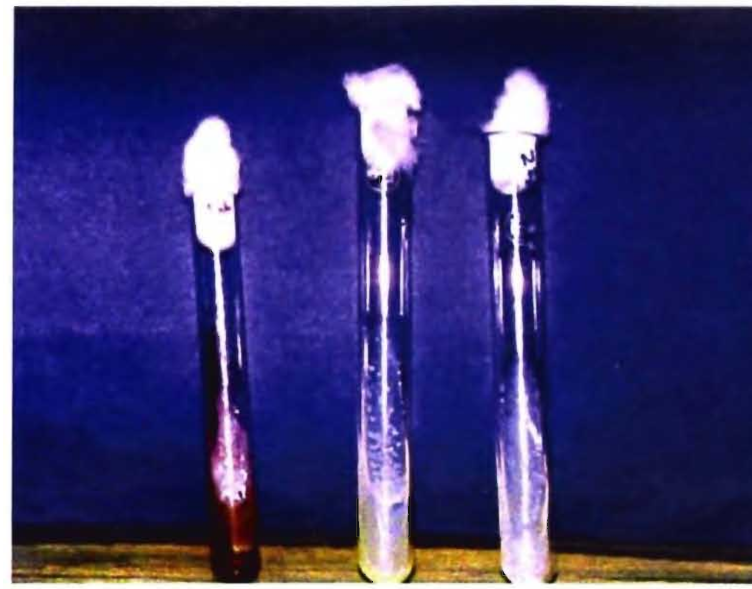
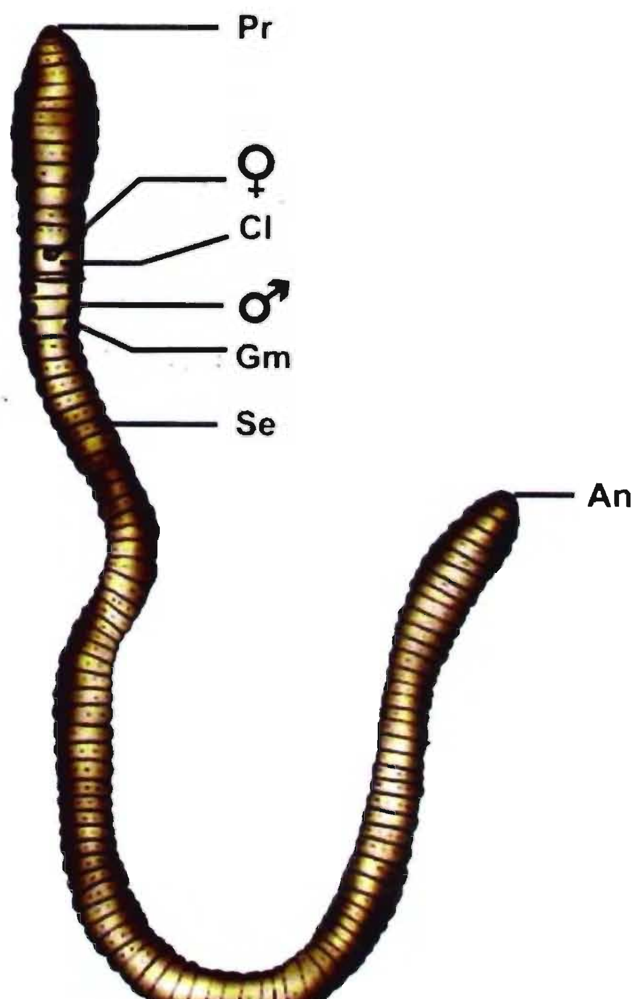


Figure b : Showing biochemical tests for isolation of pure bacterial strain



Ventral view of a typical earthworm.
Pr, Prostomium; Cl, Clitellum; Gm, Genital Marking; Se, Setae; An, Annus