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Study on the effect of textile effluent on the growth and fecundity of *Eudrilus euginiae*

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Abstract: *Eudrilus euginiae* is one among the well studied species of earthworms involved in the conversion of organic waste resources into value added products (vermicompost). Efforts were taken to understand the impact of textile effluent on the population of earthworms mimicking the condition prevalent in textile belt of Tamil Nadu, India where effluents are drained into the cultivable land through the water stream. Categories of earthworms were maintained and drained with calculated amounts of raw, chemically and biologically treated effluents for a period of eight weeks in which fecundity and growth were recorded. There was significantly high fecundity in the soil treated with raw effluent than that of control and the treated effluents suggesting us to use of these worms for bioremediation of textile effluent polluted soil.

Keywords: *Eudrilus eugeniae*; textile effluent pollution; bioremediation; fecundity; Cocoon; raw textile effluent; biologically treated effluent; hatchling.

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1 Introduction

Textile industries consume large amount of water (60–4,001/kg of fabric) and chemicals for wet processing (AEPA, 1998). The chemical reagents used in textile sector are diverse in chemical composition ranging from inorganic to organic. The inputs of wide range of chemicals, which, if not incorporated in the final products (fabric), become waste and turn out to be part of water ecology. Generally, textile effluent is coloured, varying in hydraulic flow rate, having high; pH, temperature, biological oxygen demand (BOD), chemical oxygen demand (COD), total dissolved solids (TDS) and total suspended solids (TSS) (Banat et al., 1996; Buckley, 1992; Ghoreishi and Haghighi, 2003).

Colour is imparted to textile effluents because of various dyes and pigments used. Many dyes are visible in water at concentrations as low as 1 mg/l. Textile wastewaters, typically with dye content in the range of 10–200 mg/l are therefore highly coloured. In addition to this, various salts and chemicals are major sources of heavy metals in wastewater (Wagner, 1993). Sediments, suspended and dissolved solids are important repositories for toxic heavy metals and dyes (Chapman et al., 1982; Tamburlini et al., 2002) causing rapid depletion of dissolved oxygen leading to oxygen sag in the receiving water (Ademoroti et al., 1992).

The key environmental issues associated with textile manufacture are; water use, treatment and disposal of aqueous effluent. Textile effluents are mostly discharged after minimal or no pretreatment into the adjoining water channels, streams and estuaries (Robinson et al., 2001; Yusuff and Sonibare, 2004). There is a growing emphasis on biological remediation associated with their cost effective and long lasting nature. Presently, textile belt of Tamil Nadu as popularly called had been draining their effluents into the streams and waste lands that were once cultivable until strict rules and regulations were passed to confine their effluents. Since then, the industries have been treating their effluents either by chemical treatment or using biological agents such as bacterium or fungi. However, the large quantities of water ultimately reach the ecosystem even after careful recycling and purification processes as being done recently. Since earthworms are major components in the cultivable lands where the textile industry polluted waters drain into, a study has been undertaken to record the impact of these textile dye industry effluents (raw and chemical or biologically treated) on the population of these worms. *Eudrilus eugeniae* was employed for the purpose.

2 Materials and methods

2.1 Collection of raw, chemically and biologically treated textile dye effluent

Textile dye effluents were collected from the United Bleachers Limited at Mettupalayam separately as raw effluent, chemically treated effluent and biologically treated effluent. These were brought to the lab and used for the restoration of moisture content in the earthworm medium as per the treatment regime.

2.2 Collection of earthworms, treatment and their maintenance

Earthworm, *Eudrilus eugeniae* were collected from the Periyar Research Organization for Bio-Technique & Eco-System (PROBE), Periyar Maniyammai University, Vallam, Tanjore Dist, Tamil Nadu, South India. Organic waste served as a medium of growth for the worms in the sieved garden soil and cow dung mixed in the ratio of 2:1 (Bhattacharjee and Chaudhuri, 2002). The mixture was allowed to dry under sunlight for ten hours. After mixing subsequent amount of water, the worms were allowed to be contained in suitable perforated plastic containers with the soil [Figures 1(a) and 1(b)]. The study was carried out in four groups such as the Control (Group I) receiving only tap water, Group II: receiving raw effluent, Group III receiving the chemically treated effluent and Group IV receiving the biologically treated effluent [Figures 1(c) and 1(d)]. The effluents were given for the first ten days followed by the tap water for all the groups in order to accommodate study in a small volume of soil taken in the culture-basket. The study was prolonged for a period of eight weeks with a change-over of only 30% of medium (wt/wt) at the end of four weeks. Care was taken to rear the worms with more than 80% of moisture in the immediate surroundings by automated water sprinkler. Percentage of moisture was calculated on dry weight basis after oven drying at 105°C for 24 hours by the following formula (Standards Association of Australia, 1977).

$$MC\% = \frac{WS1_1 - WS2}{WS2} \times 100$$

where,

MC moisture content of the soil

*WS*1 soil weight before oven drying in gm

*WS*2 soil weight after oven drying in gm

The optimum temperature was maintained constantly by spreading some banana leaves over the culture basket. Viability of the worms, cocoon production, hatchlings and weight of the worms were recorded for every seven days from day 1. At the time of recording, the worms were taken out gently in a cotton mesh and washed with a gentle flow of water (Bhattacharjee and Chaudhuri, 2002). For this, the soil from each basket was carefully placed on a clean white surface and the worms, cocoons and hatchlings were collected carefully and weighed or counted as appropriate.

Figure 1 Soil and cowdung mixed in the ratio of 1:1 (a) basket with many perforations to allow aeration of the soil (b) experiments conducted in triplicates (c) earthworms maintained in baskets receiving tap water (control Group I) (d) raw effluent (Group II), chemically treated (Group III) and biologically treated effluent (Group IV) (see online version for colours)

(a)

(b)

Figure 1 Soil and cowdung mixed in the ratio of 1:1 (a) basket with many perforations to allow aeration of the soil (b) experiments conducted in triplicates (c) earthworms maintained in baskets receiving tap water (control Group I) (d) raw effluent (Group II), chemically treated (Group III) and biologically treated effluent (Group IV) (continued) (see online version for colours)

(c)

(d)

3 Results and discussion

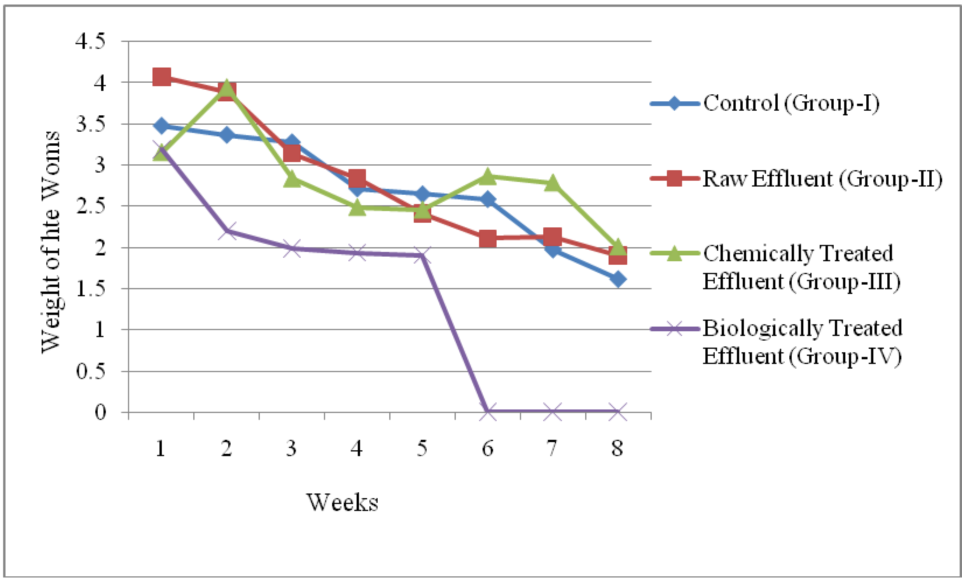
Prior to the experiment, the physicochemical characteristics of the textile wastewater were measured and the results were tabulated (Table 1). Number and weight of the worms, number of hatchlings and cocoons were recorded at an interval of seven days for eight weeks in all the treatment groups. Viability of the worms were recorded for a period of eight weeks where, worms in Group II and the Control (Group I) were all viable. Group III and Group IV worms demonstrated mortality to 33% and 100% respectively at sixth week (Figure 2). Absolute mortality observed in Group IV worms is possibly due to two main reasons. First being that the microbial load of the treated effluent. The balance between microbial invaders and the host may be shifted in favour of the invaders (used in the biological treatment) either by the elevation of pathogenicity or by the impairment of host immunity (Ewa et al., 2006). Secondly, mortality might be due to the toxic metabolites. The primary amines that are derived from the microbial decolourisation of the dyes are mutagenic and toxic to the animals, especially the lower vertebrates and the invertebrates (Chung and Stevens, 1993).

Table 1 Physico-chemical characteristics of the raw, chemically treated and biologically treated effluent with their maximum permissible limits as recommended by Indian Standards Institution

S. no.	*Parameters*	*Raw effluent*	*Chemically treated effluent*	*Biologically treated effluent*	*ISI limit for discharge of industrial effluents*	
					On land for irrigation (ISI, 1977).	*Into inland surface waters (ISI, 1974)*
1	Colour	Dark brown	Pale yellow	Light brown	-	-
2	Odour	-	-	Unpleasant	-	-
3	pH	10.2	8.7	8.0	5.5–9.0	5.5–90
4	COD (mg/l)	183	90	133	-	-
5	BOD (mg/l)	89	33	62	100	30
6	TSS (mg/l)	3000	250	3600	100	100
7	TDS (mg/l)	1700	850	5800	2100	2100

Source: ISI (1977, 1974)

Figure 2 Weight of the worms in all the groups for a period of eight weeks (see online version for colours)



The mean weight of the worms have reduced significantly ($p < 0.001$) from 3.48±0.92 to about 1.65±0.65 in the control Group I. A similar observation was made in the treatment Groups II and III also where there is a reduction in size of worms by 2–3 folds. However, in the biologically treated group (IV), there was high mortality after five weeks (Figure 3). In Group IV, in week 5, the weight of the worms reduced to nearly 3 folds when compared to the control which took eight weeks for similar observation. All the three worms in the biologically treated effluent-soil died in the sixth week itself. As a measure of the population growth, cocoon production was recorded among all the three treatments in comparison with the control. An average of 7 cocoons were seen in the control group whereas, in the Group II (raw effluent) it was raised to a maximum of 22 in the fifth week and finally were 17 at the end of eight weeks. This is a significant increase when compared to the control Group I (Figure 4). In the chemically treated effluent-soil, the number of cocoons was comparable to that in the control without any significant change. In contrast to this, there were no cocoon productions seen in the biologically treated-soil group (IV). Hatchlings were counted every seven days and there were two hatchlings at the end of four weeks in the control Group I which was significantly ($p < 0.001$) different from the (Group II) raw effluent treated-soil which produced 7 cocoons. Chemically treated and biologically treated-soil groups (III and IV) did not produce hatchlings through cocoons (Figure 5). There was significant loss in weight of the worms throughout the experimental period which is probably due to the limited space and soil available in the basket containing the soil. Chemically treated effluent-soil in Group III demonstrated stress and toxicity due to chemicals to certain levels that caused morbidity and mortality though not to the level of the biologically treated effluent-soil Group IV (Bayer and Foy, 1982; Ezemonye et al., 2006).

Figure 3 Viability of worms in all the groups for a period of eight weeks (see online version for colours)

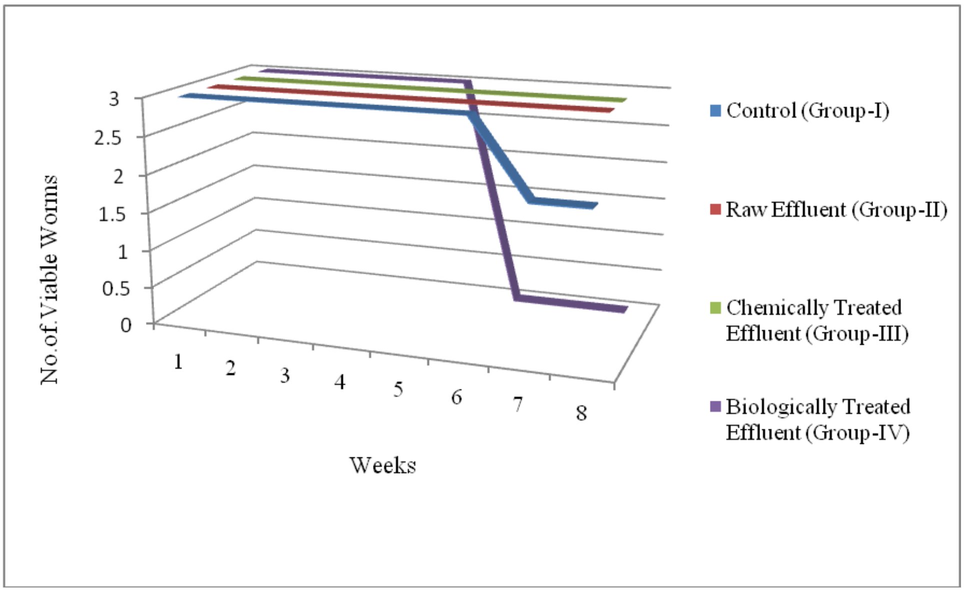


Figure 4 Number of cocoons in all the groups for a period of eight weeks (see online version for colours)

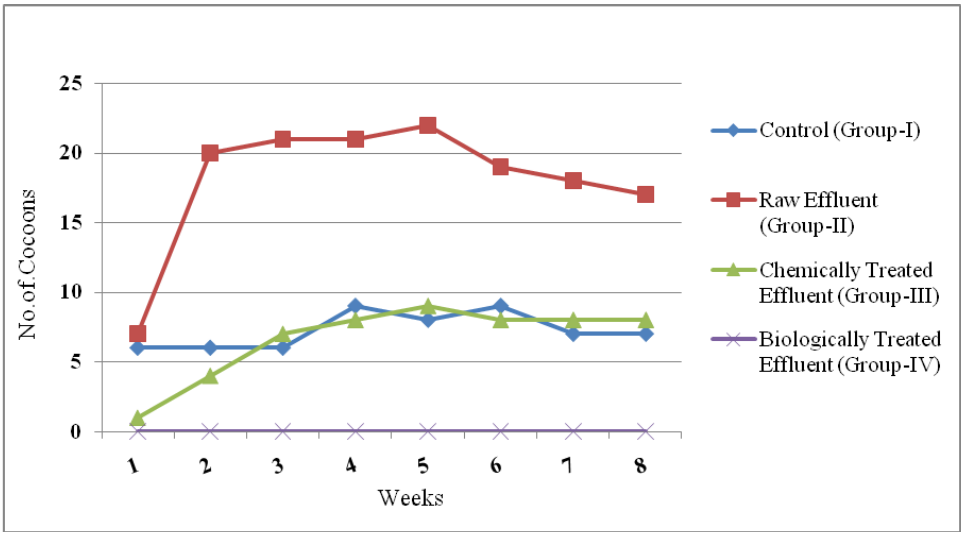
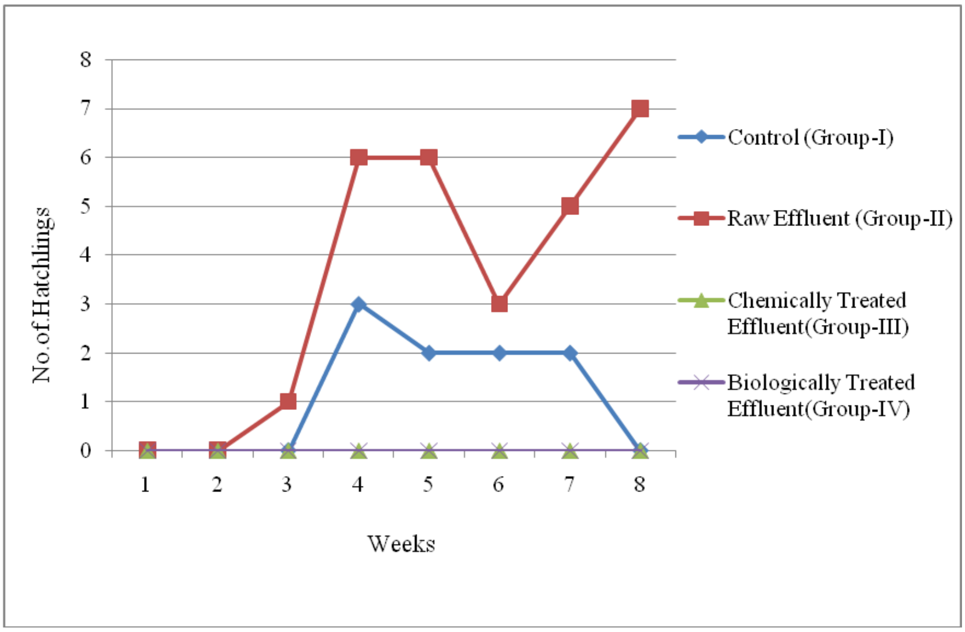


Figure 5 Number of hatchlings in all the groups for a period of eight weeks (see online version for colours)



A greater proportion (> 80%) of the biomass of terrestrial invertebrates is represented by earthworms which play an important role in structuring and increasing the nutrient content of the soil. Therefore, they can be suitable bio-indicators of chemical contamination of the soil in terrestrial ecosystems providing an early warning of deterioration in soil quality (Bustos-Obregon and Goicochea, 2001; Culy and Berry, 1995; Sorour and Larink, 2001). This is important for protecting the health of the natural environment and is of increasing interest in the context of protecting human health (Beeby, 2001) as well as other terrestrial vertebrates which prey upon earthworms (Dell'Omo et al., 1999). The suitability of earthworms as bioindicators in soil toxicity is largely due to the fact that they ingest large quantity of decomposed litter, manure and other organic matter deposited on soil, helping to convert it into rich topsoil (Reinecke and Reinecke, 1999; Sandoval et al., 2001). Moreover, studies have shown that the earthworm skin is a significant route of contaminant uptake (Lord et al., 1980) and thus investigation of earthworm biomarkers in the ecological risk assessment (ERA) can be helpful (Sanchez-Hernandez, 2006). They have also been observed to be valuable as index organisms in evaluating the impact of soil-borne contaminants (Callahan et al., 1991; Ireland, 1979; Schaefer, 2001). With the increasing rate of industrialisation and urban development, there is no doubt that the environment we live in today is exposed to greater pollution. There is a need therefore to evaluate an off-side test for assessing the impact of textile industry effluent on the activities of the earthworm species *Eudrilus eugeniae*.

From the present investigations, it is clear that the earthworms are known not to suffer significant morbidity from exposure to raw textile industry effluent. Moreover, they seem to flourish with high fecundity in the presence of raw textile effluent than that of the control water and treated effluents. This is a unique and striking finding which is different from the expected outcome indicating us to conduct further studies on testing the putative employment of earthworms in the bioremediation of such soils and their uses thereof to promote growth, development and yield of a crop plant

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