International Journal of Applied and Natural Sciences (IJANS)
ISSN(P): 2319-4014; ISSN(E): 2319-4022
Vol. 3, Issue 2, Mar 2014, 45-52

International Academy of Science, Engineering and Technology
Connecting Researchers; Nurturing Innovations

TEXTILE AND DYE INDUSTRY EFFLUENT, SLUDGE AND AMENDMENTS ON DEHYDROGENASE AND PHOSPHATASE ACTIVITY OF SOIL UNDER SUNFLOWER CROP

M. PARAMESWARI

Department of Environmental Sciences, Tamil Nadu Agriculture University, Coimbatore, Tamil Nadu, India

ABSTRACT

Gypsum, pressmud, Farm yard manure, ETP sludge were tried to ameliorate the textile and dye effluent polluted soil habitat, using sunflower (CO4) as a test crop. The sludge along with effluent irrigation added considerable quantities of cations (calcium, magnesium and sodium) to the soil system. Addition of amendments had a strong influence in enhancing the soil quality parameters like dehydrogenase and phosphatase activity of soil. Application of pressmud @ 5 t ha^{-1} along with 100 per cent GR + NPK reduced the soil ESP by 44.96 per cent. Application of 100 per cent GR + pressmud @ 5 t ha^{-1} + NPK under effluent irrigation increased the crop growth, yield attributes (head diameter, head weight, seed test weight) and yield of sunflower in effluent polluted soil habitat. The yield under pressmud amended plots was 36 per cent higher over control. Reclamation and restoration of textile dye effluent polluted soil habitat is possible by leaching the soil with 100 per cent GR followed by application of pressmud @ 5 t ha^{-1} and recommended NPK. The effluent had higher calcium and irrigating the crop with effluent for a considerable period had resulted in soil accumulation. The exchangeable cations decreased towards the harvesting stage of crop growth.

KEYWORDS: N- Nitrogen, P- Phosphorus, K- Potassium, GR- Gypsum Recommendation, ESP - Exchangeable Sodium Percentage

INTRODUCTION

Synthetic dyes are used extensively for textile dyeing, paper printing, colour photography and as additives in petroleum products (Youngless *et al*., 1985). Wastewater generated from the textile industries may contain a variety of polluting substances, such as acids, heavy metals, bases, toxic organic and inorganic dissolved solids, and colors (Butani Naresh, 2013). The wastewater characteristics depend upon the processing stages. In general, the wastewater from a typical cotton textile industry is characterized by high value of BOD, COD, colour, and pH. Because of the high BOD, the untreated textile wastewater can cause rapid depletion of dissolved oxygen if it is directly discharged into the surface water sources. The sludge resulting from different industrial operations and wastewater treatment plants are managed through destructive methods: land filling and incineration (Ndegwa and Thompson, 2001. Due to high content of calcium and sulphur in dye sludge, composting and land application have become more attractive method of disposal. Further the result of detailed sludge characterization, greenhouse studies, decomposition processes and column leaching studies showed that land application was feasible (Macyk, 1999).

The limited landfill space, more stringent national waste disposal regulations and public consciousness have made land filling increasingly expensive and impractical (Ndegwa and Thompson, 2001). The textile and dye industrial sludge is reported to promote crop growth if added to the soil in quantities below the toxicity limits. Moreover, the land application of industrial sludge provides an effective and environmentally acceptable option of waste disposal to recycle valuable nutrients into the soil plant system. Applying dye industrial sludge to agricultural land as a soil amendment or as a source of calcium and sulphate has been suggested as more desirable alternative to land fill.

MATERIALS AND METHODS

A field experiment was conducted to assess the effect of dye effluent and sludge on soil fertility and productivity of sunflower. The treatment details are given below.

I_1 – Well water

I_2 – Treated textile and dye effluent

Treatments

T_1 - Control, **T_2** - 50 per cent GR+ NPK, **T_3** - 100 per cent GR + NPK, **T_4** - 50 per cent GR+ Pressmud @ 5 t ha^{-1}+NPK, **T_5** -100 per cent GR+ Pressmud @ 5 t ha^{-1}+ NPK, **T_6** - 50 per cent GR+ ETP Sludge @ 5 t ha^{-1}+ NPK, **T_7** -100 per cent GR+ ETP Sludge @ 5 t ha^{-1} + NPK, **T_8** - 50 per cent GR+ Farmyard manure @ 12.5 t ha^{-1}+ NPK, **T_9** - 50 per cent GR+ Farmyard manure @ 12.5 t ha^{-1} +NPK

Fertilizer Dose: 40 kg N, 20 kg P and 20 kg K ha^{-1} **Design**: FRBD **Replications:** Three

The field experiment was initiated at ETP-Senepiratti, Karur, Tamil Nadu. Calculated amount of the amendments as per the treatments including the textile and dye sludge were uniformly spread in the plots and ridges and furrows were formed. Sunflower seeds (CO4) were sown adopting a spacing of 60 x 45 cm. Top dressing of NPK was carried out and irrigated once in a week. Soil samples were drawn at different intervals of field experiment and analysed for various biochemical properties as per the methods described in Table 1.

Plant biometric observations were recorded at vegetative stage, flowering stage and at harvest stage. Five plants at random were selected from each plot and tagged. The observations plant height, plant girth and number of leaves were recorded the mean values were calculated. The plant height was measured from the ground level to the tip of the growing point and expressed in cm. Quality characteristics of yield attributes like single head weight (g), Head diameter (cm), 1000 grains weight: 1000 grains of each representative samples were recorded for each treatment and expressed in g. The experimental data were statistically scrutinized to find out the influence of various treatments on the soil properties and crop growth as suggested by Panes and Sukhatme (1955). The critical difference was worked out at five per cent (0.05) probability.

Characterization of Effluent and Solid Waste from Textile and Dye Effluent

Preparation of samples for analysis **t**he sludge samples were shade dried, sieved through 2mm nylon sieve and stored in polythene bags. The samples thus prepared were analysed for their chemical properties Table 1.

Table 1: Analysis Method of Textile and Dye Industry Solid Waste and Soil Sample

S. No.	Parameters	Methods Followed
Analysis of Textile and Dye Solid Waste		
1	pH and EC	Dye sludge and distilled water @ 1:10 and measured in pH meter and conductivity meter Falcon *et al.* (1987)
2	Preparation of triacid extract	Nitric acid: sulphuric acid: perchloric acid @ 9:2:1 ratio Biswas *et al.* (1977)
3	Preparation of diacid extract	Sulphuric acid and perchloric acid @ 5:2 ratio Biswas *et al.* (1977)
4	Total nitrogen	Diacid extract - semiautomatic Kjeldahl apparatus Bremner (1965)
5	Total phosphorus	Triacid extract - vanadomolybdate yellow colour method Jackson (1973)
6	Total potassium	Triacid extract - flame photometer Jackson (1973)
Analysis of Soil Sample		
1	pH	Soil: Water suspension of 1: 2.5 Jackson (1973)
2	Available N	Alkaline permanganate method Subbiah and Asija (1956)
3	Available P	Photoelectric colourimeter at 660 nm Olsen *et al.* (1954)
4	Available K	Neutral Normal Ammonium acetate extract (Flame photometer) Stanford and English (1948)
5	Dehydrogenase	2,3,4 Triphenyl tetrazolium chloride as substrate and titration with 0.24 M Potassium permanganate till pink colour disappears Casida *et al.*(1964)
6	Peroxidase	Colorimeter, using H_2O_2 as substrate Kar and Mishra (1976)

RESULTS AND DISCUSSIONS

Field experiment was conducted at Senapirattai, Karur, Tamilnadu, India using sunflower as test crop to assess its phytoremediation efficiency in textile and dye effluent polluted soil habitat. The results obtained from the field study are discussed here under. The pH of the experimental soil was 8.10 with EC of 3.30 dS m^{-1}. The soil available N, P, K contents were 136, 12.9 and 262 kg ha^{-1}, respectively. The organic carbon content was 0.60 per cent. It also had an appreciable amount of exchangeable Ca, Mg, Na and K with the values of 13.3, 9.50, 28.6 and 0.90 cmol (p^{+}) kg^{-1} respectively.

Characteristics of Textile and Dye Effluent and Well Water Used for Irrigating the Sunflower Crop

The effluent used for the study had a pH of 6.23 with dull blue colour and EC of 3.28 dS m^{-1}. It also had an appreciable amount of nitrogen (32.0 mg L^{-1}), phosphorus (28.00 mg L^{-1}) and potassium (1.61 mg L^{-1}). The Ca, Mg and sulphate contents of the effluent were 178, 54.7 and 234 mg L^{-1}, respectively. The characteristics of the well water used for irrigation recorded a pH of 7.55, EC of 1.56 dS m^{-1}. The electrical conductivity of the soils also showed an increase due to continuous irrigation with effluent (Kannan and Oblisami, 1990). The Ca and Mg contents were 80 and 28.6 mg L^{-1}, respectively.

Initial Characteristics of Sludge and Amendments Used for the Field Experiment

The textile and dye sludge used for the study had a pH of 8.60 and EC of 4.58 dS m^{-1}. The total nitrogen, phosphorus and potassium contents were 0.18, 0.12, 1.57 percentages respectively. The Ca, Mg, sulphate and carbonate content of the sludge were 17.35, 1.85, 18.6 and 16.34 percentages, respectively. The pH of the press mud, farmyard manure and gypsum were 7.12, 7.38 and 9.78, respectively, whereas the EC values were 1.65, 0.74 and 1.85 dS m^{-1}, respectively. Among the amendments, pressmud had the highest N, P, K of 0.98, 1.87, 0.72 per cent, respectively whereas gypsum recorded 0.18 per cent of phosphorus and the highest Ca and Mg contents of 16.58 per cent and 3.38 per cent, respectively. The lowest Ca and Mg of 1.05 per cent and 0.32 per cent were recorded in farmyard manure.

Soil Characteristics as Influenced by Effluent and Amendments

Soil pH increased with advancement of crop growth in the effluent irrigated treatments while under river water the change was not at a considerable level. Similar viewpoints were also expressed by Malathi (2001). The soil pH values at vegetative stage ranged from 7.53 to 8.25. During flowering stage it ranged from 7.92 to 8.52 and at harvest stage it varied from 8.07 to 8.67. The soil reaction increased progressively till at the end of harvest stage. It might be due to continuous effluent irrigation, which was alkaline in nature. Similar increase in soil pH due to effluent irrigation was reported by Vasconcelos and Cabrel (1993). The increase in soil pH due to amendment addition, in the present study corroborates with the findings of Olaniya *et al*. (1991). The mean EC of soils ranged from 3.37 to 4.23, 3.08 to 4.17 and 2.92 to 4.09 dS m^{-1} at vegetative, flowering and at harvest stages, respectively. The treatment combination I_2T_1 recorded the highest EC value and the lowest value was observed in I_1T_3 at harvest stage. The higher EC in effluent receiving treatments might be due to salt accumulation because of continuous effluent irrigation. The increase in EC might be due to higher Ca and Mg content of sludge. These findings were in line with that of Hameed and Udayasoorian (1999). Eneji *et al.* (2002) revealed that the nitrogen mineralization was affected by both soil and manure types, they showed nitrogen mineralization was the highest in urea treated soils, and very low in manure treated soils.

Soil Enzyme Activities as Influenced by Effluent and Sludge

Dehydrogenase Activity

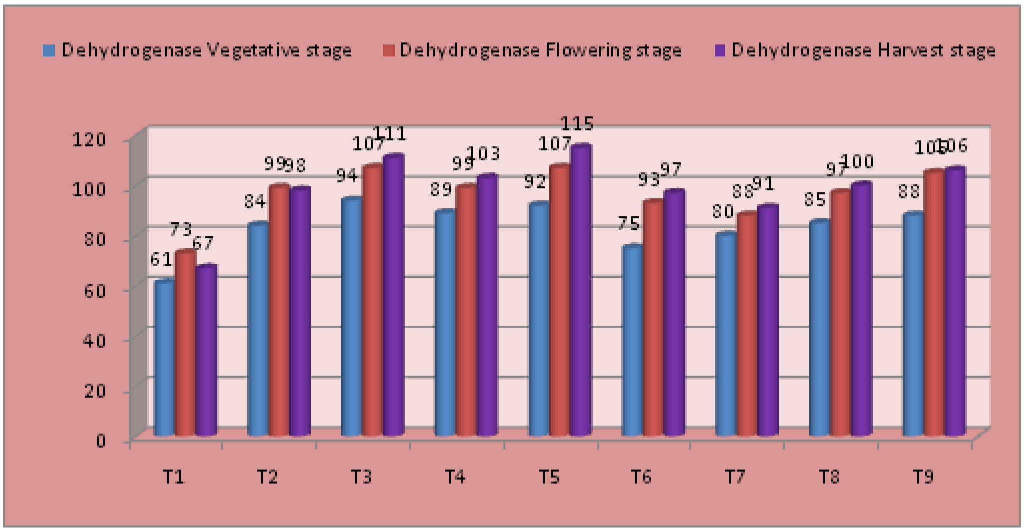
The soil dehydrogenase activity significantly differed between various treatments, and at different stages of crop growth. The highest mean dehydrogenase activity was observed in T_5 (115 μ g TPF released g^{-1} of soil) at harvest stage and the lowest enzyme activity was observed in farmer's practice (T_1) at vegetative stage (61 μ g TPF released g^{-1} of soil). Higher dehydrogenase activity was observed at harvest stage than the other stages. The interaction effect was significant at all stages. Invariably all treatments recorded higher dehydrogenase activity value under effluent irrigation than well water irrigation.

The measurement of enzyme activities provides an index of the extent of specific biochemical processes in soil and in many situations act as indicators of soil fertility and health. The activity of soil enzymes was marginally higher in the treatments, which received 5 t ha^{-1} poultry manure (T_4) than 12.5 t ha^{-1} FYM (T_3). It might be due to higher microbial load of poultry manure. It was supported by the results of Devagi *et al. (*2000) who observed an increase in organic matter content, which serves as a nutrient source for microorganisms, might increase the enzyme activity in the effluent irrigated soil. The measurement of enzyme activities provides an index of the extent of specific biochemical processes in soil and in many situations act as indicators of soil fertility and health.

The activity of soil enzymes was marginally higher in the treatments, which received 5 t ha^{-1} poultry manure (T_4) than 12.5 t ha^{-1} FYM (T_3). It might be due to higher microbial load of poultry manure. It was supported by the results of Devagi *et al. (*2000) who observed an increase in organic matter content, which serves as a nutrient source for microorganisms, might increase the enzyme activity in the effluent irrigated soil. Bhoyar *et al.* (1992) reported that waste amendments should be applied at low level to maintain a good soil physical condition. At high levels of application, soil properties were reported to be impaired due to the presence of high concentration of metals and toxic constituents. Continuous use of pulp industrial sludge over a period of 15 years to a sandy soil increased the activity of phosphatase and urease enzymes. Invertase enzyme activity increased in soils amended with pressmud and pulp industrial sludge (Palaniswami and Sree Ramulu, 1994).

Table 2: Effect of Effluent Irrigation and Amendments on Dehydrogenase (µg TPF Released g^{-1}) Activity of Soil under Sunflower

Treatments	Dehydrogenase					
	Vegetative Stage		Flowering Stage		Harvest Stage	
T_1	61		73		67	
T_2	84		99		98	
T_3	94		107		111	
T_4	89		99		103	
T_5	92		107		115	
T_6	75		93		97	
T_7	80		88		91	
T_8	85		97		100	
T_9	88		105		106	
Mean	**83**		**96**		**98**	
Interaction	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**	**SEd**	**CD (0.05)**
I	0.195	0.397	0.226	0.460	0.213	0.432
T	0.414	0.841	0.480	0.976	0.450	0.917
I x T	0.585	1.190	0.679	0.679	0.638	1.297



I_1 – Well water, I_2 - Treated textile dye effluent
T_1 – Control (NPK alone), T_2 – 50 %GR+NPK, T_3 – 100 %GR+NPK, T_4 –50%GR+PM+NPK,
T_5 – 100%GR+PM+NPK,
T_6 –50%GR+ETP sludge +NPK, T_7 100% GR+ETP sludge + NPK, T_8- 50%GR+FYM+NPK,
T_9 -100 % GR+FYM+ NPK
PM - Pressmud @ 5 t ha^{-1}, ETP sludge - Effluent Treatment Plant sludge @ 5 t ha^{-1}, FYM – Farmyard manure @ 12.5 t ha^{-1}

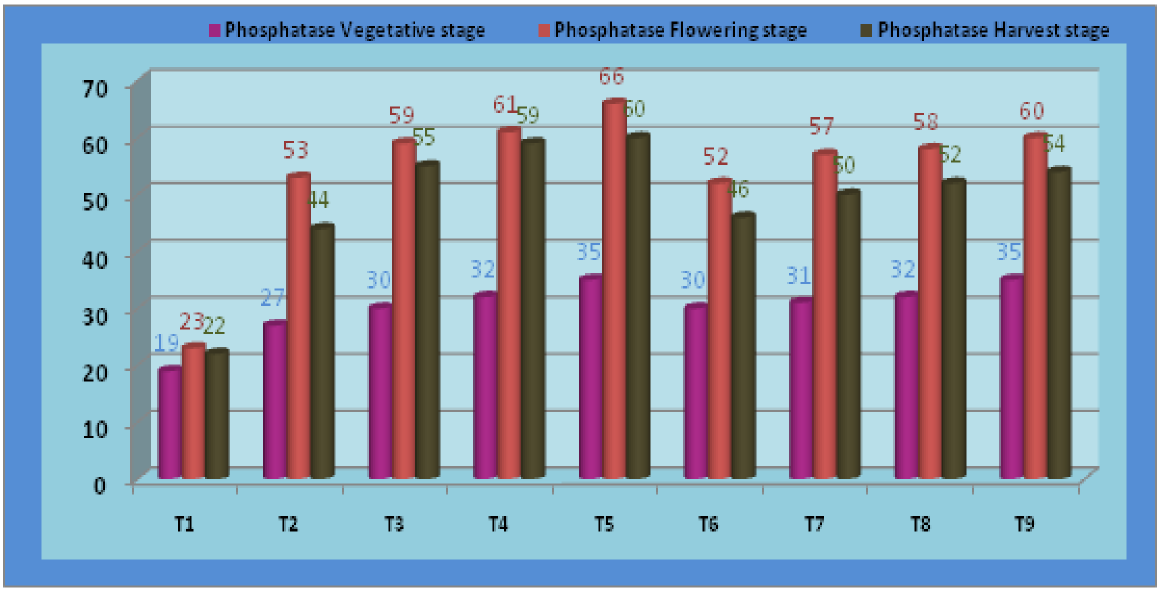
Figure 1: Effect of Effluent Irrigation and Amendments on Dehydrogenase (µg TPF Released g^{-1}) Activity of Soil under Sunflower

Phosphatase Activity

The soil phosphatase activity differed between various treatments, and at different stages of crop growth. During vegetative stage, T_5 and T_9 registered the highest phosphatase activity of 35 µg PNP released g^{-1} of soil, and they were on par with each other. During flowering stage the highest phosphatase activity was recorded in T_5 (68 µg PNP released g^{-1} of soil), it was significantly higher than the rest of the treatments, followed by T_4 and T_9. Similar trend was observed at harvest stage. The interaction effect was significant at all stages. Invariably all treatments recorded higher phosphatase activity under effluent irrigation than well water irrigation. Higher phosphatase activity during flowering stage might be due to excretion of plant root enzymes, which could be advantageous from the point of soil phosphatase activity. Reduction in dehydrogenase activity, after flowering stage, might be due to reductive state of ferric oxide as reported by Bromfield (1960) and also the enzyme activities depend on the type and physiological stage of the standing crop

Table 3: Effect of Effluent Irrigation and Amendments on Phosphatase (µg PNP Released g^{-1}) Activity of Soil under Sunflower

<table>
<tr><th rowspan="2">Treatments</th><th colspan="6">Phosphatase</th></tr>
<tr><th colspan="2">Vegetative Stage</th><th colspan="2">Flowering Stage</th><th colspan="2">Harvest Stage</th></tr>
<tr><td>T_1</td><td colspan="2">19</td><td colspan="2">23</td><td colspan="2">22</td></tr>
<tr><td>T_2</td><td colspan="2">27</td><td colspan="2">53</td><td colspan="2">44</td></tr>
<tr><td>T_3</td><td colspan="2">30</td><td colspan="2">59</td><td colspan="2">55</td></tr>
<tr><td>T_4</td><td colspan="2">32</td><td colspan="2">61</td><td colspan="2">59</td></tr>
<tr><td>T_5</td><td colspan="2">35</td><td colspan="2">66</td><td colspan="2">60</td></tr>
<tr><td>T_6</td><td colspan="2">30</td><td colspan="2">52</td><td colspan="2">46</td></tr>
<tr><td>T_7</td><td colspan="2">31</td><td colspan="2">57</td><td colspan="2">50</td></tr>
<tr><td>T_8</td><td colspan="2">32</td><td colspan="2">58</td><td colspan="2">52</td></tr>
<tr><td>T_9</td><td colspan="2">35</td><td colspan="2">60</td><td colspan="2">54</td></tr>
<tr><th>Mean</th><th colspan="2">30</th><th colspan="2">54</th><th colspan="2">49</th></tr>
<tr><th>Interaction</th><th>SEd</th><th>CD (0.05)</th><th>SEd</th><th>SEd</th><th>CD (0.05)</th><th>SEd</th></tr>
<tr><td>I</td><td>0.072</td><td>0.146</td><td>0.133</td><td>0.270</td><td>0.120</td><td>0.205</td></tr>
<tr><td>T</td><td>0.152</td><td>0.309</td><td>0.282</td><td>0.573</td><td>0.255</td><td>0.519</td></tr>
<tr><td>I x T</td><td>0.215</td><td>0.438</td><td>0.399</td><td>0.810</td><td>0.361</td><td>0.734</td></tr>
</table>



I_1 – Well water, I_2 - Treated textile dye effluent

T_1 – Control (NPK alone), T_2 – 50 %GR+NPK, T_3 – 100 %GR+NPK, T_4 –50%GR+PM+NPK, T_5 100%GR+PM+NPK,

T_6 –50%GR+ETP sludge +NPK, T_7 100% GR+ETP sludge + NPK, T_8- 50%GR+FYM+NPK, T_9 -100 % GR+FYM+ NPK

PM - Pressmud @ 5 t ha^{-1}, ETP sludge - Effluent Treatment Plant sludge @ 5 t ha^{-1}, FYM - Farmyard manure @ 12.5 t ha^{-1}

Figure 2: Effect of Effluent Irrigation and Amendments on Phosphatase (µg PNP Released g^{-1}) Activity of Soil under Sunflower

CONCLUSIONS

The combined use of manure and inorganic fertilizer increased the soil fertility that have resulted from the balanced availability of plant nutrients and humic substances, and the positive impact of each nutrient could have attributed to the higher vegetative growth as well as on yield and yield attributes. Also the addition of organic manures could have increased the efficiency of chemical fertilizers and improved the soil conditions resulting in the higher yield of crops. Based on the results obtained from the field experiment, it could be concluded that the diluted treated textile and dye effluent can be safely used for irrigation along with appropriate amendments.

REFERENCES

1. Biswas, T.D., B.L Jaian and S.C. Maldal. 1977. Cumulative effect of different levels of manures on the physical properties of soil. J. Indian Soc. Soil Sci., 19: 31-37.
2. Bremner, J.M. 1965. Inorganic forms of nitrogen. In: Methods of Soil Analysis. Part 2. C.A. Black (Eds.), Am. Soc. Agron. Inc. Wisconsin, USA, pp. 1170-1237.
3. Bromfield, S.M. 1960. Transformation and availability to rice of N and P in waterlogged soil. Adv. Agron., 20: 323-359.
4. Bhoyar, R.V., A.D. Bhide and M.S. Olaniya. 1992. Fate of heavy metals in black sewage sludge and refuse compost. *Indian J. Environ. Hlth.*, 34: 122-132.
5. Butani Naresh, Jobanputra Jaydip, Bhatiya Prabhat, Patel Rajkumar 2013. Recent Biological Technologies for Textile Effluent Treatment., Int. Res. J. Biological Sci .Vol. 2(6), 77-82
6. Casida, L.E., D.A. Klein and T. Santoro. 1964. Soil dehydrogenase activity. Soil Sci., 98: 371-376.
7. Dhevagi, P. 1996. Studies on the Impact of paper mill effluent on agro-ecosystem. Ph.D. (Environmental Sciences) Thesis, Tamil Nadu Agric. Univ., Coimbatore.
8. Eneji, A.E.J., T. Honna and F. Yamamoto, 2002. Nitrogen transformation in four Japanese soils following manure and urea amendment. Commun. Soil Sci. Plant Anal., 33: 53-66.
9. Hameed Sulaiman, S.M. and C. Udayasoorian. 1999. Metals in soil environment and the growth of *Eucalyptus* seedlings as influenced by paper mill wastes. Proc. Environmental Impacts of Metals. International workshop, Department of Environmental Sciences Tamil Nadu Agric. Univ., Coimbatore, March, 22-23. pp 41-42.
10. Jackson, M.L. 1973. Soil Chemical Analysis. Prentice Hall of India (Pvt.) Ltd., New Delhi.pp.24-36.
11. Falcon, M.A., E. Corominas, M.L. Perez and F. Perestelo. 1987. Aerobic bacterial populations and environmental factors involved in the composting of agricultural and forest wastes of the Conary Islands. Biol. Wastes., 20: 89-99.
12. Kannan, K. and G. Oblisami. 1990. Decolourisation of pulp and paper mill effluent by growth of *Aspergillus niger*. World J. Microbiol. Biotechnol., 6: 114-116.
13. Kar, M. and D. Mishra. 1976. Catalase, peroxidase and polyphenoloxide activities during senescence. Plant Physiol., 57:317-319

14. Macyk, T.M. 1999. Land application of mechanical pulp mill sludges in Alberta: research and operational activities. Pulp and Paper Canada, 100: 34-37
15. Malathi, G. 2001. Impact of Treated Pulp and Paper Mill Effluent on Vegetables – Soil Ecosystem. M.Sc. Environmental Science) Thesis, Tamil Nadu Agric. Univ., Coimbatore.
16. Ndegwa, P.M and Thompson, S.A. 2001. Integrating composting and vermin composting in the treatment of bioconversion of biosolids. *Biores. Technol*., 76: 107-112.
17. Oblisami, G. and A. Palanisami. 1991. Studies on the Effect of Paper and Sugar Factory Effluent on Soil Microflora and Agricultural Cropping System. Scheme Report. Seshasayee Paper Mill, Tamil Nadu Agric. Univer., Coimbatore, pp. 297-305.
18. Olaniya, M. S., M.P. Khandekar, I. Rahman and A.D. Bhide. 1992. Mobility of metals in soil: A case study. Indian J. Environ. Hlth., 34: 261-271.
19. Olsen, S.R., L.L. Cole, F.S. Watanabe and D.A. Dean. 1954. Estimation of available phosphorus in soils by extraction with sodium bicarbonate. U.S.D.A. – Circ. p. 939
20. Palaniswami, C. 1989. Studies on the Effect of Continuous Irrigation with Paper Factory Effluent on Soil Properties and on Sugarcane Nursery and Main Crop and Development of Techniques for Clarification of Effluent. M.Sc. (Ag.) Thesis, Tamil Nadu Agric. Univ., Coimbatore.
21. Palaniswami, C. and U.S. Sree Ramulu. 1994. Effects of continuous irrigation with paper factory effluent on soil properties. J. Indian Soc. Soil Sci., 42: 139-140.
22. Parameswari, M and C. Udayasooriyan, 2013. Influence of different concentration of textile and dye effluent and sludge on soil fertility, growth and yield of maize crop. ***J. Environ. Sci. and Sust. (JESS)*** Vol.1 (2): 61 – 65, 2013.
23. Panse, V.G and P.V. Sukhatme. 1985. Statistical methods for Agricultural workers. I.C.A.R. Publ., New Delhi, P.359.
24. Stanford, S. and L. English. 1948. Use of flame photometer in rapid soil tests of K. Agron. J., 41: 446-447.
25. Subbiah, B.V. and G.L. Asija. 1956. A rapid procedure for estimation of available nitrogen in soils. Curr. Sci., 25: 259 -260
26. Vasconcelos, E. and F. Cabrel. 1993. Use and environmental implications of pulp mill sludge as organic fertilizer. Environ. Pollution., 80: 159-162.
27. Youngless, T., J. T. Swansinger, D.A. Danner and M. Greco, 1985. Chemical dyes. Annual. Chem., 57: 1894–1902.