Madras Agric. J., 96 (1-6): 173-178, June 2009
https://doi.org/10.29321/MAJ.10.100467

# Influence of Paper Board Mill Effluent on Soil Properties

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Field survey involved collection and analysis of thirty-five soil samples representing in and around the factory areas covering Mandaraikadu, Devanapuram, Periya Thekkampatti, Chinna Thekkampatti, Chinna Kandiyur and Rangarajapuram villages. Soil samples were collected once in three months to assess the changes in soil quality parameters if any due to effluent contamination. The soil was analyzed for its chemical properties viz., pH, EC, OC, available NPK, exchangeable Ca, Mg, Na, K and DTPA Cu Fe, Mn, Zn. The microbial population of bacteria, actinomycetes and fungi were also enumerated. The pH, EC, OC, available nutrients (NPK), exchangeable cations (Ca, Mg, Na, K), ESP, SAR and CEC were high in effluent irrigated soils in and around the factory regions compared to the Bhavani river water irrigated soils. The above soil properties were increased due to continuous effluent irrigation at periodical intervals. The microbial population also increased considerably due to continuous effluent irrigation.

**Key words**: pH, EC, ESP, per cent chloride, seepage, bacteria, fungi and actinomycetes

The sustainability of environmental quality is an accepted national goal. The major efforts to maintain and sustain environmental quality are in controlling industrial pollution, treating liquid wastes, disposal of solid wastes, etc. Agriculture is also faced with a number of constraints. Land application of industrial effluent and sludge for the crop production is an effective method of waste disposal wherein the valuable nutrients are recycled back into the ecosystem. Such water reuse accomplishes several purposes such as minimizing the cost of waste water treatment and disposal, providing much needed nutrients to the soil when used for agriculture and particularly alleviating the shortfall of water supply with a dependable continuous supply of waste water.

## Materials and Methods

The Bilt-IPCL is situated in Thekkampatti village, Mettupalayam, Coimbatore District, Tamil Nadu. Coimbatore lies in 11.02$^0$ North latitude and in 77.03$^0$ East longitudes. The mean annual rainfall is 700 mm. Soil is of red loamy type and classified as Typic Ustalf. River Canals and wells are the main sources of irrigation in this region.Five hundred grams of soil samples at 0-30 cm depth were collected once in three months to assess the changes in soil quality parameters if any, due to effluent contamination. Soil samples were dried in shade for two days, powdered gently with a wooden mallet and sieved through a 0.2 to 2 mm sieve. The material, which passed through the sieve, was taken for further analysis. The pH, EC, OC, available nutrients (NPK), exchangeable cations (Ca, Mg, Na, K), ESP, SAR and CEC were analysed as per the standard procedure. The microbial population was also enumerated.

## Results and Discussion

The pH of the soil increased progressively in all soils, which was acidic to neutral in nature. The mean pH of the soil samples collected at periodical intervals increased from 6.69 to 6.86 due to continuous Bilt-IPCL effluent irrigation, whereas the values in river water irrigated soils ranged from 7.02 to 7.15. The highest pH was observed in March 2001, which might be due to retention of more ions in the soil due to evaporation loss. Among the villages, Rangarajapuram recorded the highest pH value,

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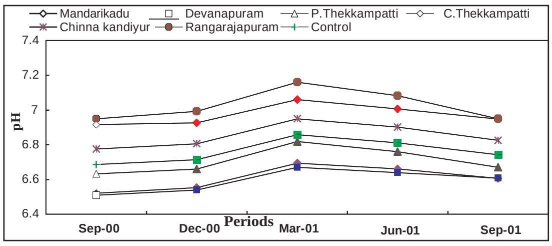
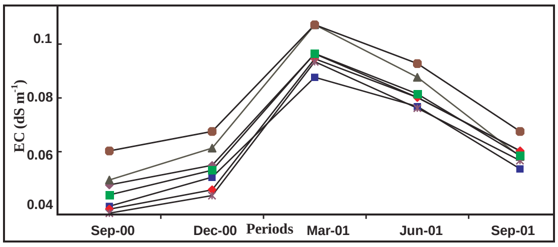
which was located near the treated effluent irrigated area (Fig. 1). The seepage of water from Mandaraikadu where the effluent was applied directly to sugarcane crop might have increased the soil pH at Rangarajapuram. This is in line with the findings of Kannan and Oblisami (1989) who reported that the soil reaction increased while irrigating with undiluted paper factory effluent.

**Fig 1. pH of soil samples in and around the Factory area**




The EC of the soils in around the factory area was high (0.05-0.10 dS $m^{-1}$) compared to river water irrigated soil. The highest EC was recorded in the month of March 2001(summer). The soluble salt concentration decreased during the monsoon seasons (December 2000, and 2001). Mandaraikadu (factory site) recorded the highest EC values because of the continuous effluent irrigation. Rangarajapuram also recorded the highest EC values because of its proximity to factory site. Due to high evaporation loss in summer (March 2001), the soil EC increased invariably in all the villages. During monsoon season, the soil EC decreased due to leaching of soluble salts (Fig. 2). The increase in soluble

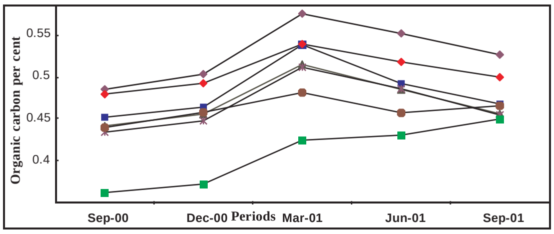
**Fig 2. EC of soil samples in and around the Factory area**




salt content in the soil could be ascribed to the salt content of effluent. Reddy *et al.* (1981) have also reported that continuous irrigation with pulp and paper mill resulted in increased soluble salts in soil. Similar observations were also reported by Udayasoorian *et al.* (1999a) in TEWLIS area near Karur where the treated paper mill effluent was continuously used for irrigation over eight years.

Soil samples in and around the factory area recorded more organic carbon (0.46-0.53 per cent) compared to river water irrigated soil. Among the villages, Mandaraikadu (factory site) recorded higher organic carbon content than other villages (Fig 3). The organic carbon content was increased during the month of March 2001. A gradual increase in soil organic carbon content in these villages might be due to accumulation of suspended and dissolved organics present in the

**Fig 3. Organic carbon per cent of soil samples in and around the Factory area**




effluent which inturn contribute to the built up of organic matter. Similar observations were made by Udayasoorian *et al*. (1999b) in TEWLIS area where the treated paper mill effluent was used for irrigation. Available nutrient status (except available K) of the soil in and around the factory area was higher when compared to river water irrigated soil (Table.1). An increasing trend on available nutrient status was observed invariably at all the villages due to the impact of continuous effluent irrigation at Mandaraikadu from where the seepage water containing more of N and K pollutes the other villages also.

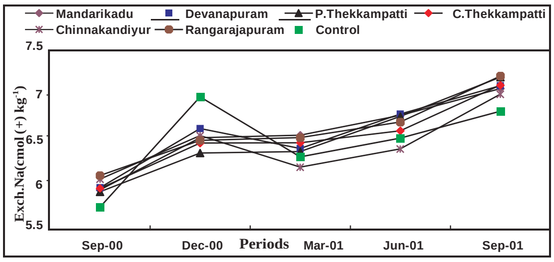
Exchangeable sodium content was low in the river water irrigated soils compared to effluent irrigation. The mean exchangeable sodium was found to be 5.98, 6.50, 7.11, 6.41, and 6.68 cmol (+) $kg^{-1}$ at September 2000, December 2000, March 2001, June 2001 and September 2001 respectively in Bilt-IPCL effluent irrigated soil in and around the factory area. The sodium content was very high in Rangarajapuram during the period

**Table 1. Available N (kg $ha^{-1}$) of soil samples in and around the factory area**

| Location | Sep-00 | Dec-00 | Mar-01 | Jun-01 | Sep-01 | Mean |
|---|---|---|---|---|---|---|
| Mandarikadu | 135 | 135 | 138 | 136 | 136 | 136 |
| Devanapuram | 142 | 140 | 146 | 142 | 143 | 142 |
| P.Thekkampatti | 145 | 144 | 148 | 144 | 146 | 145 |
| C.Thekkampatti | 144 | 142 | 144 | 145 | 144 | 144 |
| Chinna kandiyur | 153 | 151 | 151 | 149 | 143 | 149 |
| Rangarajapuram | 147 | 145 | 145 | 143 | 139 | 144 |
| Mean | 144 | 142 | 145 | 143 | 142 | 143 |
| Range | 115-162 | 112-161 | 112-162 | 106-160 | 111-161 | 111-160 |
| SD | 11.0 | 11.5 | 11.5 | 11.7 | 10.7 | 10.9 |
| SE | 1.9 | 2.0 | 2.0 | 2.0 | 1.8 | 1.9 |
| Control(river water) | 141 | 142 | 141 | 139 | 135 | 140 |

of March 2001.Similar trend of increase in soil exchangeable calcium was observed in effluent irrigation compared to river water irrigation. The river water irrigated soils recorded higher exchangeable magnesium content than the effluent irrigated soils. The exchangeable potassium content was less in river water irrigated soil compared to effluent irrigated soil. Soil exchangeable cations (Na, Ca, Mg and K) were increased in considerable quantity in and around the factory area when compared to river water irrigated soils. The exchangeable cations increased with duration of effluent irrigation (Fig 4). The fast movement of soluble ions present

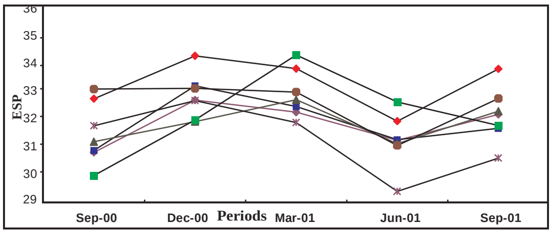
**Fig 4. Exchangeble Na (cmol (+) $kg^{-1}$ of soil samples in and around the Factory area**




in effluent through seepage water to other nearby villages might have been the reason for increased exchangeable cations. Higher concentration of exchangeable cations under effluent irrigation was reported by a number of workers (Reddy *et al.*, 1981; Gomathi and Oblisami, 1992). Effluent irrigation for over three years increased exchangeable cations in soil (Palaniswami, and Sree Ramulu, 1994)

The ESP of the soil samples collected in and around the factory region irrigated by Bilt-IPCL effluent was higher than that of river water irrigation. The ESP of soil samples in and around the factory area was above 30. Presence of higher proportion of sodium in soil samples might have contributed to the increased values of ESP. Chinna Thekkampatti recorded higher ESP values invariably in all seasons except September 2000. Chinna Thekkampatti and Rangarajapuram showed higher ESP values when compared to the factory site of Mandaraikadu (Fig.5). This is due to the accumulation of more organics in the lower elevation, which might retained more of

**Fig 5. ESP of soil samples in and around the Factory area**




cations especially the sodium in soil. This is in line with the findings of Palaniswami (1989) and Alfred (1998).

The mean per cent chloride values at different location in and around the factory area ranged

**Table 2. Available P (kg $ha^{-1}$) of soil samples in and around the Factory area**

| Location | Sep-00 | Dec-00 | Mar-01 | Jun-01 | Sep-01 | Mean |
|---|---|---|---|---|---|---|
| Mandaraikadu | 28.75 | 27.96 | 28.61 | 28.69 | 27.08 | 28.22 |
| Devanapuram | 28.53 | 27.94 | 28.22 | 28.09 | 27.38 | 28.03 |
| P.Thekkampatti | 29.75 | 28.47 | 29.51 | 29.50 | 28.11 | 29.07 |
| C.Thekkampatti | 30.48 | 28.97 | 30.30 | 30.29 | 28.45 | 29.70 |
| Chinna kandiyur | 31.66 | 30.08 | 31.40 | 30.98 | 29.57 | 30.74 |
| Rangarajapuram | 31.46 | 29.12 | 31.30 | 28.41 | 26.84 | 29.43 |
| Mean | 29.88 | 28.65 | 29.66 | 29.33 | 27.94 | 29.09 |
| Range | 25.4-33.6 | 24.9-31.5 | 25.1-33.3 | 23.7-32.6 | 23.3-30.8 | 25.1-32.2 |
| SD | 2.12 | 2.00 | 2.13 | 2.55 | 2.16 | 2.00 |
| SE | 0.36 | 0.34 | 0.37 | 0.44 | 0.37 | 0.34 |
| Control(river water) | 28 | 28 | 29 | 29 | 26 | 28 |

from 0.012 to 0.015. It was comparatively higher than the soil samples of river water irrigation (Table 3). Among the locations, Chinna Thekkampatti, Rangarajapuram and Devanapuram recorded higher percent chloride than the other villages. The per cent chloride was maximum during summer season (March, 2001). Similar trend was also observed in CEC of soil samples and the

**Table 3. Per cent Chloride of soil samples in and around the Factory area**

| Location | Sep-00 | Dec-00 | Mar-01 | Jun-01 | Sep-01 | Mean |
|---|---|---|---|---|---|---|
| Mandarikadu | 0.012 | 0.013 | 0.015 | 0.013 | 0.013 | 0.013 |
| Devanapuram | 0.012 | 0.014 | 0.016 | 0.014 | 0.013 | 0.014 |
| P.Thekkampatti | 0.011 | 0.013 | 0.016 | 0.014 | 0.013 | 0.013 |
| C.Thekkampatti | 0.013 | 0.013 | 0.016 | 0.014 | 0.013 | 0.014 |
| Chinna kandiyur | 0.011 | 0.012 | 0.015 | 0.013 | 0.012 | 0.013 |
| Rangarajapuram | 0.013 | 0.014 | 0.015 | 0.014 | 0.013 | 0.014 |
| Mean | 0.01 | 0.01 | 0.02 | 0.01 | 0.01 | 0.01 |
| Range | 0.011-0.013 | 0.011-0.015 | 0.013-0.018 | 0.011-0.016 | 0.011-0.015 | 0.012-0.015 |
| SD | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| SE | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Control(river water) | 0.013 | 0.014 | 0.015 | 0.013 | 0.013 | 0.013 |

values ranged from 20.6-23.1 cmol (+) $kg^{-1}$ during March, 2001. The mean SAR was high in the soil samples collected in the effluent irrigated soil and the SAR values ranged from 3.3 to 3.9 compared to river water irrigated soils. The SAR of the soil was less than 4 cmol $L^{-1}$ and falls the category of 'low' under continuous effluent irrigation over a period of one year (Fig.6). Similar findings have

**Fig 6. SAR of soil samples in and around the Factory area**

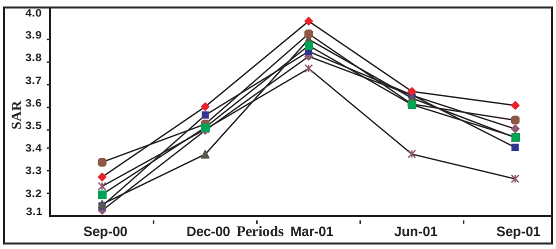


**Table 4. Bacterial population( X $10^6$ g $^{-1}$ CFU) of soil samples of in and around the Factory area**

| Location | Sep-00 | Dec-00 | Mar-01 | Jun-01 | Sep-01 | Mean |
|---|---|---|---|---|---|---|
| Mandarikadu | 17 | 20 | 26 | 24 | 23 | 22 |
| Devanapuram | 18 | 21 | 26 | 24 | 22 | 22 |
| P.Thekkampatti | 19 | 21 | 27 | 25 | 24 | 23 |
| C.Thekkampatti | 22 | 24 | 28 | 27 | 26 | 25 |
| Chinna kandiyur | 21 | 23 | 27 | 25 | 24 | 24 |
| Rangarajapuram | 23 | 24 | 29 | 28 | 27 | 26 |
| Mean | 19 | 22 | 27 | 25 | 24 | 24 |
| Range | 15-27 | 17-28 | 24-31 | 21-31 | 19-30 | 19.8-29 |
| SD | 3.17 | 2.73 | 1.82 | 2.15 | 2.47 | 2.34 |
| SE | 0.54 | 0.47 | 0.31 | 0.37 | 0.42 | 0.40 |
| Control(river water) | 14 | 16 | 20 | 19 | 17 | 17.2 |

been reported by Pushpavalli (1990), which might be due to the build up of exchangeable calcium and magnesium in effluent irrigated soils.

***Soil microflora***

Soil irrigated with Bilt-IPCL effluent recorded higher microbial load than river water irrigated soil. The mean bacterial population for different periods increased from 19 to 25 x $10^6$ $g^{-1}$ of dry soil in the effluent irrigated soil while in the river water irrigation it increased from 14 to 20 x $10^6$ $g^{-1}$ of dry soil. Considerable amount of fungi and actinomycetes (Table 5 & 6) were also present in effluent and river water irrigated soils. A similar trend of increase in microbial population was also noticed in fungi and actinomycetes at periodical intervals and also at different locations of in and around the factory area. This was due to the heterotrophic nature of these microbial groups, which would assimilate various constituents of waste water and proliferate in the soil. These results corroborates with the findings of Sopper and Seakar (1987), Kannan (1988) and Alfred (1998).

**Table 5. Fungal population ( X $10^4$ CFU $g^{-1}$ ) of soil samples of in and around the factory area**

| Location | Sep-00 | Dec-00 | Mar-01 | Jun-01 | Sep-01 | Mean |
|---|---|---|---|---|---|---|
| Mandaraikadu | 4 | 4 | 5 | 5 | 6 | 5 |
| Devanapuram | 4 | 4 | 4 | 5 | 6 | 5 |
| P.Thekkampatti | 4 | 4 | 5 | 5 | 6 | 5 |
| C.Thekkampatti | 4 | 4 | 5 | 5 | 6 | 5 |
| Chinna kandiyur | 4 | 4 | 5 | 6 | 6 | 5 |
| Rangarajapuram | 4 | 5 | 5 | 6 | 6 | 5 |
| Mean | 4 | 4 | 5 | 5 | 6 | 5 |
| Range | 3.0-5.0 | 3.0-5.0 | 4.0-6.0 | 4.0-7.0 | 5.0-7.0 | 3.8-6.0 |
| SD | 0.67 | 0.65 | 0.74 | 0.70 | 0.67 | 0.52 |
| SE | 0.12 | 0.11 | 0.13 | 0.12 | 0.11 | 0.09 |
| Control(river water) | 2 | 3 | 3 | 4 | 4 | 3.2 |

**Table 6. Actinomycetes population (X $10^3$ CFU $g^{-1}$) of soil samples of in and around the factory area**

| Location | Sep-00 | Dec-00 | Mar-01 | Jun-01 | Sep-01 | Mean |
|---|---|---|---|---|---|---|
| Mandarikadu | 2 | 2 | 2 | 3 | 3 | 2 |
| Devanapuram | 2 | 3 | 3 | 3 | 2 | 3 |
| P.Thekkampatti | 2 | 3 | 3 | 2 | 3 | 3 |
| C.Thekkampatti | 2 | 2 | 3 | 3 | 3 | 2 |
| Chinna kandiyur | 2 | 2 | 2 | 3 | 3 | 2 |
| Rangarajapuram | 1 | 2 | 2 | 3 | 3 | 2 |
| Mean | 2 | 2 | 2 | 3 | 3 | 2 |
| Range | 1.0-3.0 | 1.0-4.0 | 2.0-4.0 | 1.0-4.0 | 1.0-4.0 | 1.8-3.0 |
| SD | 0.73 | 0.68 | 0.66 | 0.97 | 0.80 | 0.35 |
| SE | 0.13 | 0.12 | 0.11 | 0.17 | 0.14 | 0.06 |
| Control(river water) | 1 | 1 | 2 | 3 | 2 | 1.8 |

## Conclusion

The pH, EC, OC, available nutrients (NPK), exchangeable cations (Ca, Mg, Na, K), ESP, SAR and CEC were higher in effluent irrigated soils in and around the factory regions compared to the Bhavani river water irrigated soils. The above soil properties increased due to continuous effluent irrigation at periodical intervals of analysis. The microbial population also increased considerably due to continuous effluent irrigation.

## Reference


Alfred, R.S. 1998. Impact of Paper and Pulp factory effluent on soil, water and plant ecosystem. Ph.D. Thesis, Tamil Nadu Agricultural University, Coimbatore.

Gomathi, V. and Oblisami, G. 1992. Effect of pulp and paper mill effluent on germination of tree crops. Indian *J. Environ. Hlth.,* **34**: 326-328

Kannan, K. 1988. Ecological studies on the pulp and paper mill effluent irrigation to sugarcane soil and microbial degradation of lignocellulosics in the effluent. M.Sc. Thesis, Tamil Nadu Agrl. Univ., Coimbatore.

Kannan, K. and Oblisami, G. 1989. Impact of paper and pulp mill effluent on sugarcane soil. In: Fifth National Convention of Environmental Engineers. Madras, India. Sep. 23-24.

Palaniswami, C. and Sree Ramulu, U.S. 1994. Effects of continuous irrigation with paper factory effluent on soil properties. *J. Indian Soc. Soil Sci.,* **42**: 139-140.

Pushpavalli, R. 1990. Studies on the characterization of pulp and paper mill effluent and it's effect on soil profile characteristics and on germination, yield and juice quality of sugarcane (Var. CO 63004 and COC 671) M.Sc. (Ag.) Thesis, Tamil Nadu Agrl. Univ., Coimbatore.

Reddy, M.R., Jivendran, S. and Jain, S.C. 1981. Paper mills effluent for sugarcane irrigation. IAWPC *Technol. Annu.,* **8**: 129-146.

Sopper, W.E. and Seaker, E.M. 1987. Sludge brings life to microbial communities. *Biocycle,* **28**: 40-47.

Udayasoorian, C., Dhevagi, P. and Ramaswami, P.P. 1999a. Case study on the utilization of paper and pulp mill effluent irrigation for field crops. *In* Proc. Workshop on Bioremediation of Polluted Habitats, Tamil Nadu Agricultural University, Coimbatore, March 22-23, 1999. p. 71-72

Udayasoorian, C., Mini, K. and Ramaswami, P.P. 1999b. Bagasse pith compost - An effective ameliorant in paper mill polluted soil environments. *In* Proc. Workshop on Bioremediation of polluted habitats, Tamil Nadu Agricultural University, Coimbatore, March 22-23, 1999. p .73-75.



Manuscript number : 199/08

Date of receipt : December 23, 2008

Date of acceptance : May 25, 2009