Changes in Physico-Chemical Characters of the Bedding Material Soil During Vermifiltration of Paper Mill Effluent

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***Abstract* :** The paper mill wastewater is having various types of pollutants which can create pollution if not treated properly. In this study it subjected to vermifiltration, a novel technique of waste water treatment. Here during vermifiltration, the changes if at all, in the physicochemical characteristics of soil has been studied. Further alteration of such parameters in the bedding material in the presence of earthworms has also been studied. To evaluate the effect of wastewater soil parameters i.e., pH, Electrical Conductivity, Nitrogen (N), Phosphorous (P), Potassium (K), Organic Carbon (OC), CO_2 evolution from the soil have been studied. Three soil beds have been prepared and used for the vermifiltration of paper mill waste water. One soil bed was taken as a control filtration bed (CFB), the second one was the effluent filtration bed in the absence of earthworm (EFB) while the third bed was treated with paper mill effluent in the presence of earthworms (EVB). All the soil parameters in the EFB were higher than CFB and EVB. After the application of earthworm 2% to 10% decrease in the parameters was found.

***Keywords* -** Vermifiltration, *Octochaetona surensis*,Paper Mill Effluent, pH, EC, NPK, CO_2

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I. INTRODUCTION

Soil, the skin of the earth is composed of mixtures of sand, silt, clay, minerals, air, water, organic components and is a house of millions of macro and micro-organisms. It is a necessary system of the terrestrial ecosystem. But now a day's extensive progress in civilization and industrialization has brought the menace of soil pollution. In present day, paper mills take the lion share from among the large-scale industries throughout the globe. During the process of paper making a large volume of water is used and ultimately by virtue of which huge amount of effluent is produced. With respect to the consumption of freshwater, the paper and pulp industry holds 3rd rank followed by the metallurgy industry and chemical industry (**Asghar et al, 2008**). Approximately 75% to 95% of effluent discharged by the paper and pulp industries contains high amounts of organic matter (**Trivedy and Raj, 1992**). The effluent generated by the industries many a time while discharged to the large water bodies they have the chance to come in contact with the soil. Effluent carries lots of pollutants which get percolated into the soil during its flow over the soil surface. Coming in contact with the soil, the pollutants cause changes in the physicochemical properties of the soil and interfere in its metabolic processes. They also cause harm to soil fauna and flora. A scrutiny of the works of literature of **Kannan and Oblisami 1990; Narasimha et al,1999; Singh et al,2013** on the discharge of industrial effluents on the soils strongly indicates that they cause a remarkable change in physicochemical, biological, and soil enzyme activities.

II. MATERIALS AND METHODS

The paper mill effluent was collected from the discharge channel of the Emami Paper Mill and stored in sterilized plastic containers. After collection of paper mill effluent, it was introduced into the beds which had been prepared for the evaluation of the effect on soil. Filtration beds have been prepared taking plastic containers of size 34cm length, 24cm breadth, and 5.5cm height with slits underneath. Each bed was prepared taking gravels of 1.5 cm then sand of 1 cm then above which i.e., at the topsoil was taken about the thickness of 3 cm. In each bed, soil is taken as bedding material.

The earthworms were introduced into the soil, which were acclimatized for 7 days. The soil which was used for the preparation of bed had been collected from barren land, dried and powdered. Three beds were prepared, one is called control filtration bed (CFB), the second is effluent filtration bed (EFB), and the third one is effluent vermifiltration bed (EVB). Control filtration bed was prepared with soil with distilled water but without earthworm and effluent. Effluent filtration bed was prepared by using soil bed with application of paper mill effluent but without earthworms. Effluent vermifiltration bed was prepared by application of paper mill effluent, and release of fifty numbers of earthworms of the species *Octochaetona surensis* in the soil.

The moisture (60±5%) and temperature (30±5°C) of all the beds were maintained. A regulatory system was attached to all the beds to regulate the effluent and water flow rate. The following parameters of the bedding material soil were evaluated i.e., pH, EC, N, P, K, organic carbon, and evolution of CO_2, to assess the metabolic activities going on in the bedding soil. The pH and Electrical Conductivity (EC) were measured by calibrated electrode-based digital pH meter and conductivity meter respectively. Total Nitrogen was determined by micro Kjeldahl method. Phosphorus was determined by **Bray's and Kurtz (1945)** method. Potassiumwas determined by the Flame-photometry method followed by **Toth and Prince (1949)**. The organic carbon content of soil was determined by the **Walkley-Black method (1934).** Carbon dioxide evolution from the bedding material was measured by **Witkamp (1966)** and **Mishra and Dash (1982)**.

III. Results and Discussion

There were remarkable changes in the soil physicochemical characteristics of the bedding material; the soil. In this study changes in soil properties of EFB and EVB as compared to CFB were analysed. The pH of CFB soil was 7.1, EFB soil was 7.8 and in EVB the pH of the soil was 7.6 (**Fig. 1**). The pH of EFB and EVB soil was slightly increased as compared to the soil of CFB. This increase in pH of EFB and EVB might be due to the alkaline nature of the paper mill effluent. **Juwarkar and Subrahmanyam (1987)** had worked on the consequences of wastewater on soil and plant life (crop) generated by the paper and pulp industry. In their findings the pH ranged between 7.6 to 8.4; EC was in between 1.8 to 2.5 mmhos/cm. **Yan and Pan (2010)** reported that the effect of pulp wastewater irrigation increases the pH of soil significantly. **Adrover et al (2012)** examined the effect of wastewater on the pH of the soil and concluded that the introduction of wastewater into the soil increases the soil pH value from 8.2 to 8.5. **Kumar et al (2015)** found that in bore well water applied soil the pH was 8.20±0.11, **Yadav and Chandra (2018)** had experimented on paper mill effluent impact on sediment soil of river and concluded that sediment soil of Gola river had shown that the pH of the sediment was ranged between 7.05±0.28 to 7.45±0.37., near the industrial area. As compare to EFB soil, EVB soil pH was slightly declined. This may be due to the presence of earthworm in soil where they might have released acidic substances from their body which might be the cause in decrease the soil alkalinity.

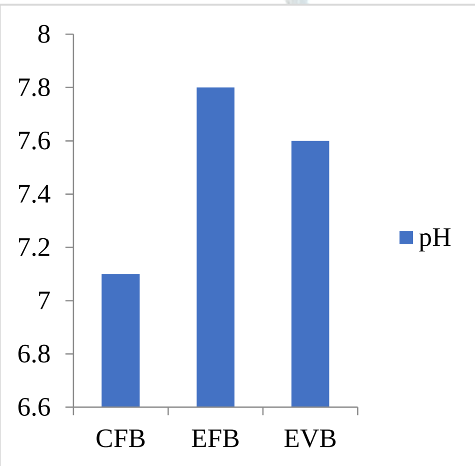

Figure 1:Soil pH of CFB, EFB & EVB

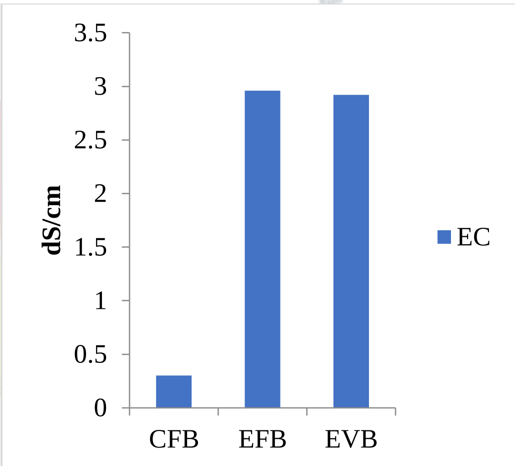

Figure 2: Soil EC of CFB, EFB & EVB

The electric conductivity of the CFB soil is 0.3 ds/M and it increased to 2.96 ds/M and 2.3 ds/M in EVB soil (**Fig. 2**). Thus increase in EC might be due to the chemicals present in the effluent which might have added to the ionic transaction in the bedding material. An increase in EC in effluent soil might be due to the presence of sodium, calcium and magnesium ions. **Liang et al 2014** examined the effect of various industrial effluents such as chemical industry, electronic industry, and textile industry on soil properties. In their findings, they have found that soil EC in river water irrigated soil was higher in four sites as compared to the control soil. **Kumar et al (2015)** found that in bore well water applied soil the EC was 2.08±0.07 dS/m. **Kumar and Chopra in 2011** concluded that the effluent of distillery industry increases the EC of the soil with respect to its concentration. But in comparison to EFB soil and EVB soil, the EC was declined in EVB soil. The possible reason behind this was the presence of earthworms which might have used the mineral during their activities.

Nitrogen content in soil CFB was 0.284%, in EFB it was 0.298% and in EVB it was 0.292% (**Fig. 3**). **Baziramakenga et al (2001)** was experimented on the effect of de-inking sludge on soil properties i.e., chemical and biochemical parameters. After the application of compost produced from de-inking sludge and poultry manure the soil inorganic nitrogen was increased than control. **Chhonkar et al (2000)** had found that application of paper mill effluent increases the nitrogen content in soil which ranges in between 180 kg/ha to 270 kg/ha. Before the treatment of effluent, the soil total Kjeldahl nitrogen was 31.38±2.38 mg/kg but after the application of paper and pulp industry effluent, the total Kjeldahl nitrogen reached 52.32±5.54 mg/kg which is increased by 66.73% **Kumar et al (2015)**. **Yadav and Chandra (2018)** had experimented on paper mill effluent impact on sediment soil of river and concluded that sediment soil of Gola river had shown total nitrogen was 16±0.67 ppm, near the industrial area. As compared to control soil, in vermifiltration bed soil the inclined nitrogen content was found. This might be due to the synergistic effect of earthworm and microbes and addition of mucus, excretory materials derivatives of nitrogen, enzymes which adds additional nitrogen into the soil (**Singh et al 2016)**.

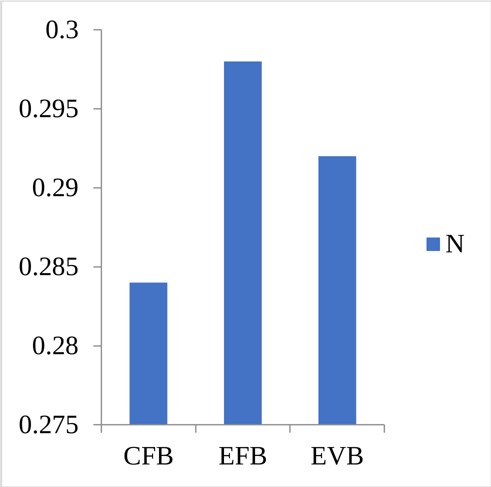

Figure 3: Nitrogen content of soil in CFB, EFB & EVB

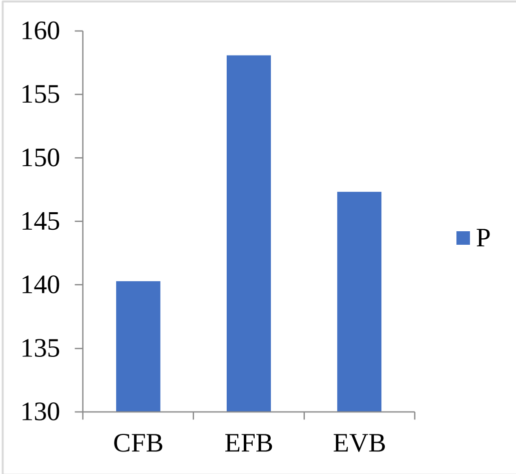

Figure 4: Phosphorous content of soil in CFB, EFB & EVB

Available Phosphorous content in CFB soil was 140.28 ppm which was increased to 158.08 ppm in EFB soiland 147.33 ppm in EVB soil (**Fig. 4**). **Mohammad and Mazahreh (2003)** and **Mandal et al (2008)** concluded that the availability of soil Phosphorus increased in wastewater-treated soil. Municipal Wastewater treated soil had more phosphorous than control soil was reported by **Adrover et al (2012)**. The PO_4^{3-} content was 6.98±1.21 mg/kg, in the soil treated with effluent **(Kumar et al, 2015). Yadav and Chandra (2018)** had experimented on paper mill effluent impact on sediment soil of river and concluded that sediment soil of Gola river had shown phosphate of 172±3 ppm near the industrial area. This increase of phosphorous level in treated soil probably is due to the addition of organic matter from effluent to soil i.e., mineralization of organic matters produced a large amount of plant-available forms of phosphorus into soils. After the application of earthworm, the phosphorous content was decreased. This might be due to the absorption of phosphorous into the skins of earthworm or by the consumption of them.

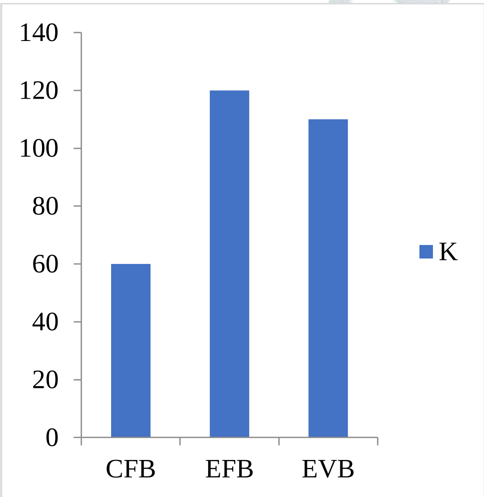

Figure 5: Potassium content of soil in CFB, EFB & EVB

In the CFB, EFB and EVB soil potassium was 60ppm, 120ppm and 110ppm, respectively (**Fig. 5**). The application of paper mill effluent increased the soil potassium but later it declined when earthworm was introduced. **Chhonkar et al (2000)** was found that potassium content was ranged in between 176 kg/ha to 328 kg/ha when paper mill effluent was introduced in soil. **Garg et al (2006)** concluded that vermitechnology can be used as an alternative methodology for the minimization of the sludge of textile industry by using *E. foetida*with making a mixture with biogas plant slurry. **Kumar et al (2015)** reported that as compared to the control soil which showed 24.03mg/kg of K^+,the effluent treated soil exhibited 154.09±5.8 mg/kg potassium. **Yadav and Chandra (2018)** had experimented on paper mill effluent impact on sediment soil of river and concluded that sediment soil of Gola river had show potassium of 31.68±2 ppm, near the industrial area. Paper mill effluent might have added potassium to the bedding soil. Reduction of potassium in EVB than EFB might be due to intake of potassium by the worms.

The organic carbon of CFB soil was 2.84% which was slightly increased in EFB soil i.e., 2.96% and EVB soil i.e., 2.92% (**Fig. 6**). This increased in OC is probably due to the presence of organic materials in effluent. **Kannan and Oblisami (1990)** concluded that organic carbon of paper mill effluent irrigated soil was increased from 0.28% to 1.23% with respect to control.

Total organic carbon of pulp wastewater irrigated soil increased i.e., in control soil it was 0.86 and it was increased to 1.86 which was due to the presence of organic materials in the effluent (**Yan and Pan, 2010). Kumar et al (2015)** found that the organic carbon content of the soil was 0.43±0.1 mg/kg which is 38.7% higher than that of bore well water applied soil. However application of earthworm had declined the organic carbon percentile in EVB as compared to EFB. The declined values in organic carbon might be due to the consumption by the earthworm.

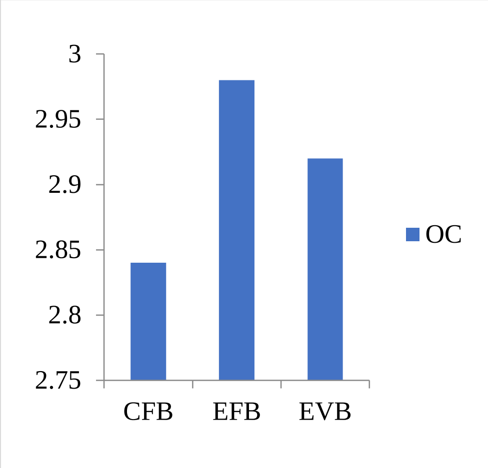

Figure 6: Organic Carbon content of soil in of CFB, EFB & EVB

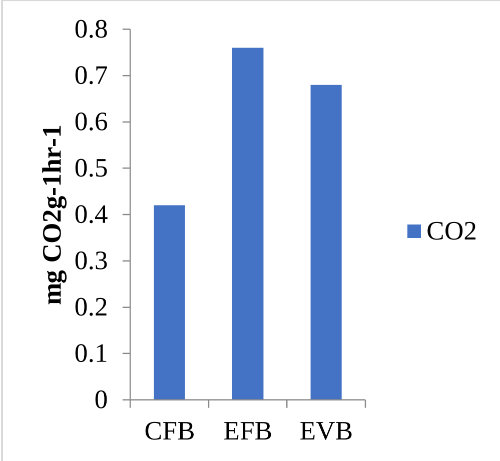

Figure 7: CO_2 evolution from soil of CFB, EFB & EVB

Evolution of Carbon Dioxide from soil increased in EFB and EVB as compared to CFB i.e., in CFB it was 0.42mg CO_2g^{-1}soil hr^{-1}, in EFB it was 0.76mg CO_2g^{-1} soil hr^{-1} and in EVB it was 0.68mg CO_2g^{-1}soil hr^{-1} (**Fig. 7**). **Yan and Pan (2010)** opined that soil respiration rate increased when paper mill wastewater was introduced to the soil in different concentrations. **Roohi et al (2016)** experimented on varied effects of untreated textile wastewater on soil and found that increased CO_2 activity with respect to the effluent concentration and incubation period. The increase in respiration rate might be due to the high microbial activity in EFB soil as compare to CFB and EVB. Afterwards the application of earthworm had declined the soil respiration. Similarly in this study, the CO_2 evolution rate was increased in EVB as compared to the CFB. The possible reason behind the inclined nature of soil respiration might be due to high microbial activity due to stress conditions. Earthworm activity might have reduced the stress to some extent by addition of some amount of organic materials to the bedding soil.

IV. Conclusion

The present study had elaborated that application of paper mill effluent has increased the pH, Conductivity, NPK, organic carbon and CO_2 evolution of the bedding material soil. Presence of earthworms in the filtration bed has reduced the parameters to some extent showing their importance. During the method of vermifiltration of paper mill effluent, the soil becomes enriched with some elements as studed and the presence of earthworm has made a balance. Earthworms can be used in possible remediation method for the minimization of physicochemical properties of soil due to the application of paper mill effluent. In near future, vermifiltration will be highly applicable and economically viable method for wastewater treatment.

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VI. References

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