

CHANGES IN SOME PHYSICAL PROPERTIES OF SOIL AMENDED WITH EFFLUENT OF EMAMI PAPER MILLS LOCATED AT BALGOPALPUR, BALASORE, ORISSA

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ABSTRACT

Paper mill effluent has been amended to the soil in laboratory conditions. Physical properties like bulk density, porosity and water holding capacity of the soil changed with respect to the concentration of the effluent. With increase in concentration of the effluent, a significant decrease in the bulk density was observed. There was an increase in porosity of amended soil with increase in the amount of effluent. The water holding capacity of the soil also increased with increase in the concentration of the effluent. So far as the days of exposures are concerned no significant difference in the bulk density, porosity and water holding capacity of the amended soil was observed.

INTRODUCTION

In recent years the use of papers and paper products has been increased to its maximum. It exerts pressure of equal magnitude on the environment. It is known that paper mills produce effluents which are discharged to the environment and cause pollution. Paper mill effluents are characterized by colour and the presence of suspended solids, bad smell, high concentration of nutrients that cause eutrophication of receiving waters (Lacorte *et al.*, 2003). The effluent generated from the industries present health hazards and disturbs the ecology if disposed without proper treatment (Mobius, 1989; Adholeya *et al.*, 2006; Suchitra *et al.*, 2006). These effluents cause considerable damage to the receiving waters, if discharged untreated since they have high bio-chemical oxygen demand, chemical oxygen demand, chlorinated compounds, suspended solids, fatty acids, tannins, resin acids, lignin and its derivatives (Escalante, 2005). Even after more than 30 years of consistent efforts, a satisfactory treatment of these effluents still remains elusive (Ali and Sreekrishnan, 2001). The water once used for industrial purpose; without any physical, chemical as well as biological treatment cannot be used further for other purposes. (Suryanarayan and Jayakumar, 2005). Much works have not been done on the effect of paper mill effluent on soil. In recent years, the demand for waste water re-use has increased significantly world wide. The effluent from paper industry may have percentage of lignin, cellulose, hemicellulose, chlorolignin, tannin, resin acids, fatty acids, sodium sulphate, calcium carbonate (Hocking, 1991). It is also reported that fibrous material used

in pulp and paper industry consists of less than 50% cellulose, minerals, extractive organic acids, and inorganic salts which are not recovered during treatment. Such paper industry effluents are either disposed into rivers or used on land irrigation (Bansal and Khare, 1990). In the present study paper mill effluent has been applied to soil to know its environmental potential.

MATERIALS AND METHODS

Emami Paper Mills is located at Balgopalpur in Balasore district of Orissa state. The industry discharges its effluent outside after treatment. Effluent sample was collected from a discharge point out side the industry. The effluent was applied to the soil in laboratory conditions in different concentrations to study some physical characteristics of the soil. Twenty earthen pots were taken for the experiment. Each pot contained three kilogram of dried powdered and sieved garden soil. All the pots were divided in to five sets with four replicates in each set. The first set was taken as control set where 750 mL of distilled water was added to each pot. Other sets were called as treated sets in which paper mill effluent was amended along with distilled water. To each pot of second set, 50 mL effluent with 700 mL water was amended. The third set received 100 mL effluent and 650 mL water. The fourth set received 200 mL effluent with 550 mL water and the fifth set was amended with 400 mL effluent along with 350 mL distilled water. The moisture content of each pot was maintained at 25 (\pm 5) % throughout the experiment. The soil samples from each pot were collected at the interval of 15 days for analysis up to 60 days. Soil physical characteristics like bulk density, porosity

and water holding capacity were studied by volumetric and gravimetric methods following Brady and Well, (2005).

RESULTS AND DISCUSSION

Bulk density

The bulk density of the control soil *i.e.* without effluent amendment was 1.23 mg/m^3 and it was decreased as the concentration of the effluent increased (Fig. 1). In highest concentration of effluent the bulk density of the amended soil was lowest *i.e.* 0.35 mg/m^3 in sixty days. In 50ml amended soil, the bulk density was 1.09, 1.05, 0.99 and 0.95 mg/m^3 in 15days, 30days, 45days and 60days respectively. In 100 mL effluent amended soil it was 0.93, 0.85, 0.78 and 0.75 mg/m^3 in 15days, 30days, 45days and 60days respectively. In 200mL effluent amended soil, the bulk density of the treated soil was 0.71, 0.68, 0.63 and 0.58 mg/m^3 whereas in case of 400mL it was 0.47, 0.43, 0.39, 0.35 mg/m^3 in 15days, 30days, 45days and 60days respectively. Decrease in bulk density facilitates root growth. It is not resistant to root penetration. Movement of nutrients and water is increased with decrease in bulk density. Bulk density depicts the proportionate value of the volume of dry soil to the weight of the soil. Depending upon the soil texture the fluctuation in bulk density is seen. Because of less aggregation of the solid particles in sandy soil less organic matters are seen. Of course, the bulk density is higher in it than the textured soils.

Bulk density is affected by organic matter content, soil organisms and plant growth materials (Brady and Well, 2005). Reports are available on the relation of bulk density with pore space (Lyon *et al.*, 1982, Tiessen *et al.*, 1982). Increase in bulk density is an inverse function of pore space. In the present study, a significant decrease ($F=3.978$; $p \leq 0.05$) in the bulk density was observed when the concentration of the effluent increased. So far as the days of exposure are concerned no significant difference in the bulk density of the treated soil was observed. The reduction in bulk density with concentration may be due to the organic matter present in the effluent; which has been added to the soil when its concentration is increased with respect to days of exposure. Organic matter has become an additive substance and increased the volume of the soil under effluent amendment there by decreasing the bulk density.

Porosity

The porosity of the soil is expressed in percent pore space. It

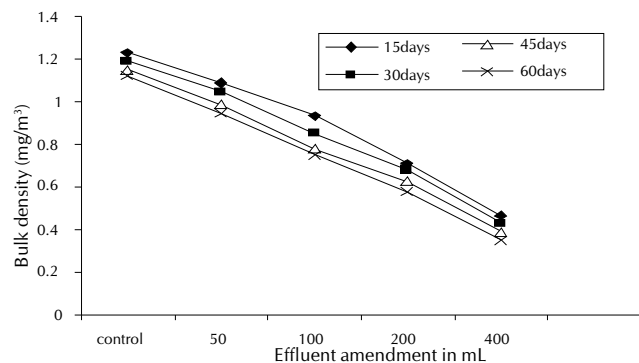


Figure 1: Bulk density of soil amended with paper mill effluent

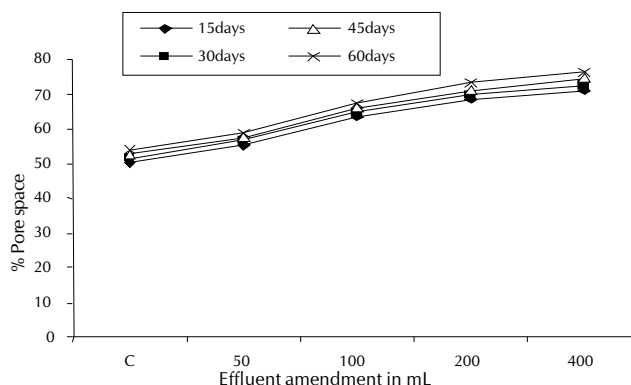


Figure 2: Porosity of soil amended with paper mill effluent

was found to be 50.2 in control soil after 15 days and was gradually increased as the concentration of the effluent increased. Percent pore space in 400mL effluent amended soil was 71.2 after 15 days. After 60 days, it was 54.2% in control soil; whereas, in 50,100,200 and 400ml effluent amended soil it was 58.9, 67.4, 73.2 and 76.1% respectively (Fig. 2). Porosity of soil is an important physical parameter which helps in determining the quality of soil. Size, shape and interconnection of pores in the soil are of great importance in determining soil drainage, aeration and other such processes (Brady and Well, 2005). Macropores are created by earthworms, plant roots and other organisms. They help in the movement of water and air freely. Arable soils consist of solids in the form of mineral particles and organic matter and pore space that is occupied by water and gas (Martens, 2000; Six *et al.*, 2000). Soils therefore, consist of matter in three phases-solid liquid and gases. The actual solids as such do not vary materially, yet the proportion of solids to liquid and liquid to gases in soil under crops is constantly changing (Gustafson, 2005). In the present investigation, there was an increase in porosity of treated soil with increase in the amount of effluent. It may be due to the utilization of materials in the effluent by soil organisms and movement of soil organisms including earthworms.

Water holding capacity

The water holding capacity of soil *i.e.* θ_v ($\text{m}^3 \text{H}_2\text{O}/ \text{m}^3 \text{soil}$) treated with different concentrations of paper mill effluent is shown in Fig. 3. In control soil the water capacity was measured to be 2.1 on 15 days of observation. After 15 days, the water holding capacity was found to be 3.5, 4.9, 6.3 and 8.6 in

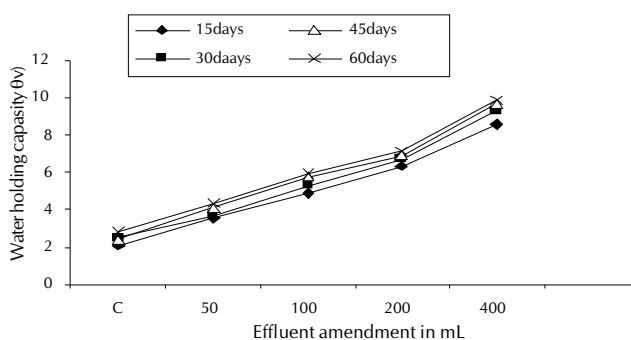


Figure 3: Water holding capacity of the soil treated with paper mill effluent

50,100,200 and 400mL effluent amended soil respectively. After 60 days of exposure, in 50,100, 200, and 400mL effluent amended soil, it was 4.3, 5.9, 7.1 and 9.8 respectively. The water holding capacity is increased significantly ($F = 3.934$; at $p \leq 0.05$) as the concentration of the effluent increased.

Water holding capacity of soil is an important parameter so far as soil quality or cropping is concerned. The presence of water in soil is essential for survival and growth of plants and other soil organisms. Soil rich in organic matter have greater water holding capacity.

Lacorte *et al.*, (2003) reported that organic matters are present in the paper mill processed water and effluent. In the present investigation, increase in the concentration of the paper mill effluent might have increased the organic matter content of the soil which has lead to the increased water holding capacity of the experimental soil. Further, water is also held within soil pores with varying decrease of tenacity. The attraction between water and surface of soil particles greatly restricts the ability of water to flow. The water in the intermediate sized pores can move towards plant roots. Earthworms are a major component of soil fauna communities in most ecosystems and comprise a large proportion of macro fauna biomass. Their activity is beneficial because it can enhance soil nutrient cycling through the rapid incorporation of detritus into mineral soils. In addition to this mixing effect, mucus production associated with water excretion in the gut of earthworms also enhances the activity of other beneficial soil microorganisms. This is followed by the production of organic matter (Brown *et al.*, 2000; Lavelle and Spain, 2001). In the present investigation, the water holding capacity of the soil also might have been increased because the effluent has resulted increased movement of earthworms thereby creating more space for water.

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