An Influence of Wastewater Discharges from Paper Mills on Farm Practices

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An Influence of Wastewater Discharges from Paper Mills on Farm Practices

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Abstract

Industrial development is a challenging issue in recent times, as its adverse impact directly influences the environment. Paper and pulp industries are generally declared as one of the highly polluting industries in the country. However, nowadays they are also identified as the industry mounting with environmental and economic pressures to reduce the volume and toxicity of generated industrial wastewaters. Paper industries generate varieties of contaminants depending upon the manufacturing process. Especially, disposal of polluted water directly affects the soil structures, not only in industrial area but also in agricultural fields. Therefore, the present work accentuates on the examination of paper effluent characteristics, its impact on soil quality and germination of groundnut seedlings. Seedling growth in polluted soil and fertile soil were monitored for 90 days. For this process, effluent, soil samples were collected from the paper industry located in Coimbatore district, Tamil Nadu, India. Soil samples were tested for their nutrients' level, concentration of heavy metals as per the standard quality procedures. Distribution of nutrients, heavy metal concentrations were studied in the matured crop sprouts. Sample crop registered mixed concentration of nutrient levels / heavy metals against the prescribed WHO / FAO standards whereas control crop exhibited values within standards sufficing its healthier growth. This implies that the irrigation of the farmland with industrial water alters nutrient availabilities, inturn promoting toxic leachates into the soil. Further, the soil performances due to the percolation of industrial discharges reflected in the complexities of crop growth.

1. INTRODUCTION

Environment sustainability is attained through hygienic environs which include unpolluted air, wholesome water and dirt-free land for survival. In this perception, water and food that we consume in our daily life are certainly inevitable assets. As earth population continues to grow, ever-increasing demand for these resources are encountered. Major basis for this change is due to over consumption of raw materials for

societal upliftment. This leads to an undesirable change in the physico-chemical and biological characteristics of environment (1). Such alteration leads to pollution transpired by keen industrial development. Pulp and paper industries are categorized as one of the 12 most polluting industries in India. Wastes generated during pulping process possess the potentiality to pollute water and land sources, since they release environmentally hazardous effluent containing heavy metals and other organic toxicants. Polluted water directly affects soil, not only in industrial areas but also the nearby agricultural fields, as well as river beds, creating secondary sources of pollution. Pulp residues rich in nutrients, heavy metals (Zinc, Copper) affect water, soil, plants; further become a health hazard to living organisms (2,3). Heavy metals above the prescribed concentrations have been declared as toxins (4). Considerable amount of essential nutrients in pulp wastes may prove beneficial for plants, whereas heavy metal accumulation and other edaphic factors turn into priority pollutants. Impact of untreated paper effluent is explored through collection of effluent sample from an industry in Coimbatore district, determination of effluent characteristics, its effect on nature of soil and assessment of adverse growth in groundnut seed germination using wastewater and soil environs against its control.

2.0 MATERIALS AND METHODS

Mapping of the location for the identified pulp and paper industry in Coimbatore district is shown in figure 1.

Figure 1 Industry Location – Mapping

Wastewater sample (figure 2) was collected during the four seasons throughout the year from the chosen industry in a well cleaned polythene bottle. The sample was subjected to physicochemical studies pertaining to varying parameters viz., pH, Total Alkalinity (TA), Total Hardness (TH), Biochemical Oxygen Demand (BOD), Chemical

Oxygen Demand (COD), Total Solids (TS) including Total Suspended Solids (TSS), Total Dissolved Solids (TDS) by using the standard methods of wastewater analysis (5). Heavy metal concentrations [Zn(II), Cu(II)] of the sample were determined using Atomic Absorption Spectrophotometer.

Figure 2 Wastewater Discharges

A total of four soil samples (figure 3) in the vicinity of the industrial campus were collected parallel mid-way between the months of February to March, June to July, September to October, November to December for thorough investigation covering a wide spectrum of their impact during all the four seasons. Sampling was done at a depth of approximately 10 - 15 cm in pre-cleaned containers and oven - dried at 70°C. The dried samples were tested at Seeds Enviro Labs, Coimbatore for their nutrient contents and heavy metal concentrations.

Figure 3 Soil Samples

Pot culture experiments were designed in such a way that two pots were filled, with contaminated and fertile soil, both of sandy clay loam texture. Groundnut seeds (*Arachis hypogaea*) were washed first in running water to remove the seed coats and later 5 – 6 seeds were sown in the pots. Pot 1 and 2 labelled as sample and control were sprinkled on alternate days for a period of 3 months, with wastewater generated from paper industry and clean water respectively. Growth of the germinated seeds was monitored every fortnight. Pictorial representations of the experimental set up for germination (figure 4) and growth of groundnut seeds are shown below,

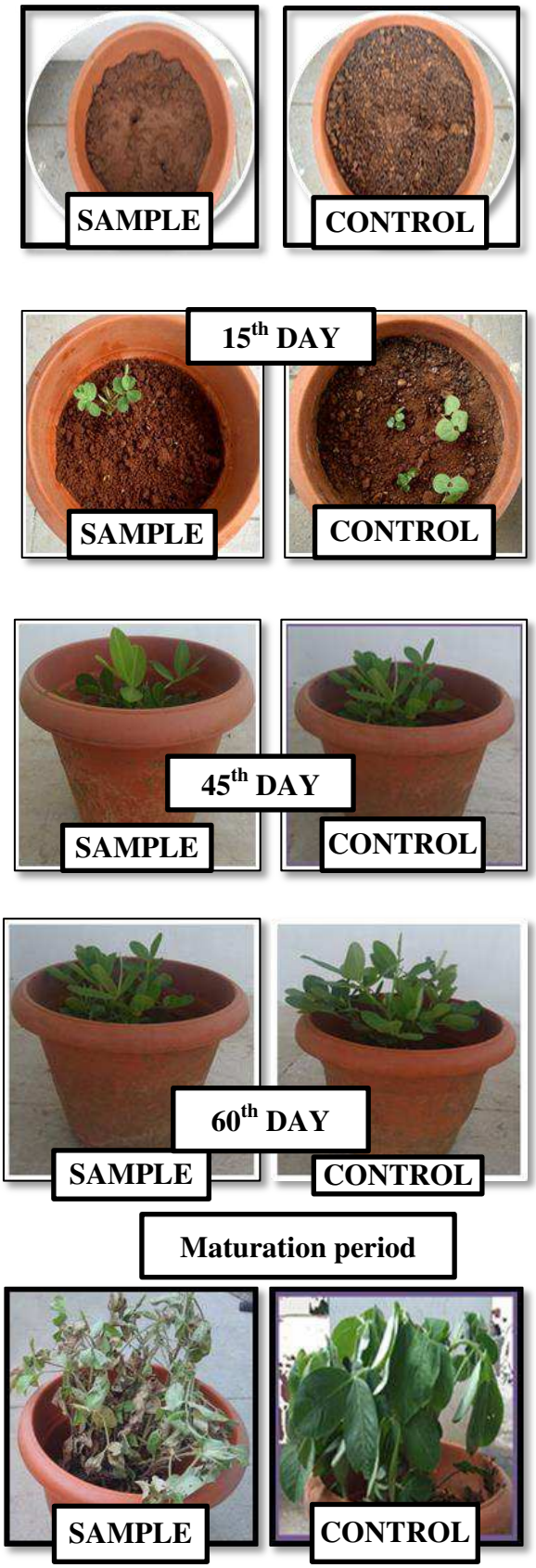

Figure 4 Germination - Experimental Setup

Later the crop shoots from both the pots were cut and their lengths were measured. Further, the shoots were thoroughly washed and minced into pieces. One gram of the dried samples were digested (110 °C) in 5 mL diacid mixture (HNO_3: $HClO_4$ = 3 : 2) for 8 hours (6). The digested samples were made upto 50 mL in a standard flask using double distilled water. The made up sample was filtered using Whatman-42 filter paper and tested for their nutrients composition and occurrence of heavy metals.

3. RESULTS AND DISCUSSION

Wastewater and Soil Analysis

Values of seasonal analyses for wastewater sample collected from pulp and paper industry located at Coimbatore district, is listed in Table I.

TABLE I. Wastewater Characteristics

Parameters	CPCB Standards	Feb - Mar	June - July	Sep - Oct	Nov - Dec
pH	5.5 – 9.0	7.5	7.71	8.25	8.95
TA	200	179	165	137	113
TH	500	728	576	540	715
DO	< 8	6.9	6.4	6.1	6.4
COD	350	1615	940	890	880
BOD	100	319	392	172	223
TS	1500	326	329	285	471
Zn(II)	15	28.2	25.5	26.1	25.3
Cu(II)	5	3.10	5.31	5.61	5.24

From the observations made, it is inferred that the sample registered a slight alkaline nature during spring and winter seasons. Nearness of pH value to the maximum permissible limit in the post monsoon season could be attributed to the fact of acute accumulation of chemicals like hydrogen peroxide, caustic soda, soap in the suspended forms. Data pertaining to few of the tested parameters viz., Total alkalinity (TA), Dissolved Oxygen (DO), Total Solids (TS) were within the prescribed standards. However, the sample recorded exceeding concentrations of other studied factors like Total Hardness (TH), Chemical Oxygen Demand (COD) and Biochemical Oxygen Demand (BOD). Usage of lightening agents, sizing substances and salts of calcium, magnesium may be the prime cause for elevated hardness values. Similarly, presence of recalcitrant organic compounds in the wastewater may contribute to the surpassing COD values (7). Pronounced BOD values during pre-monsoon seasons imply the occurrence of ample organic matter, which inturn induce greater biological activity (8). As far as heavy metal determination is concerned, the sample exhibited marginal increase in Cu(II) concentration but for Zn(II), the existence level was higher.

Results of industrial soil samples tested (Table II) reveal that except phosphorus content the values recorded for pH, secondary nutrients and organic carbon (OC) indicate greater level than the tolerance limit. Inclined pH values can be owed to the intense utilization of bleaching additives in the processing unit at the industrial outlet (9). Marked increase in calcium (Ca), magnesium (Mg) and sulphur (S) concentrations throughout the

year, suggests the nature of the soil to be a poor food crop producer. Significant variation in organic carbon content induces soil toxicity, thereby diminishing the crop yield. However, Nitrogen (N), Potassium (K), Zn(II), Cu(II) concentrations showed a deficit numeral. The ascend / descend shifts in primary nutrients (N, K) are reflected by the alkaline soil pH. Soil deficiencies due to decreased levels of contents result in the failure of utilizing the maximum available nutrients leading to plantae disease (10, 11). Variation in soil pH alters the solubility of micronutrients [Zn(II), Cu(II)] precipitating them as hydroxides, carbonates or certain insoluble complexes (12), thence, heavy metal concentration are found to be lesser than the CPCB prescribed levels.

TABLE II. Soil Characteristics

Parameters	Soil Standards	Feb - Mar	June - July	Sep - Oct	Nov - Dec
pH	5.8 - 8.3	9.36	9.05	9.48	9.55
N	2.3 – 2.8	1.1	1.02	1.22	1.3
P	0.1 – 1	0.38	0.15	0.42	0.47
K	1.3 – 2	0.52	0.01	0.52	0.47
Ca	< 1	7.94	8.7	7.98	8.38
Mg	< 0.5	3.89	0.31	4.02	4.09
S	0.5	3.12	0.06	3.16	3.31
OC	< 2.5	36.2	14.1	41.3	44.3
Zn(II)	0.0300 – 0.0600	0.004	0.004	0.005	0.004
Cu(II)	0.0135 – 0.0270	0.006	0.007	0.007	0.006

Germination Trials Outcome of analyzed shoot sample against control is listed in Table III. Unfavoured variations were observed for the case of primary and secondary nutrients, indicative of diminished soil fertility. Also, it is evident that metal infusion had occurred from polluted soil into the grown crop. Registered values of control crop within the standards obviously suffice healthy grown of groundnuts.

TABLE III. Nutrient / Heavy Metal content - Sprouted crops

Parameters	Standards (%)	Crops	
		Sample	Control
pH	5.8 – 8.3	6.11	6.93
N	2 – 5	1.22	2.01
P	0.2 – 0.5	0.15	0.40
K	1 – 5	0.44	1.10
Ca	0.1 – 1	0.05	1.13
Mg	0.1 – 0.4	0.07	0.31
S	0.1 – 1.3	0.03	1.21
Zn(II)	0.002 – 0.010	0.023	0.009
Cu(II)	0.004 – 0.005	0.0071	0.003

4. CONCLUSION

Pulp and paper industrial wastewater sample collected from an industry in the locales of Coimbatore was subjected to systematic analysis of physicochemical parameters and

heavy metal concentrations. Total hardness (TH), Chemical Oxygen Demand (COD), Biological Oxygen Demand (BOD) and divalent metal ions registered higher values than the permissible limits as per CPCB Standards. Soil quality for the sample procured from the industrial zone was analyzed during four seasons. Marked dissimilarities were noticed in the nutrient values as per the data provided by Indian agricultural standards. Impact of these polluted soil and wastewater samples were verified by germinating groundnut seeds with respect to a control. Inhibitive fluctuations in the values of primary and secondary nutrients were obvious from the tested shoot of the sample, reflecting in retarded soil fertility, when compared with that of the shoot test conducted for control sample. It is therefore concluded that lethargic disposal of industrial wastes without proper pre-treatment paves way to utmost contamination of the soil and water quality, thereby leading to inclined risks associated to the environment.

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