

Pulp and Paper Industrial Discharges on Soil Environs in Crop Nutrients' Management

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Abstract

Pulp and paper industry is considered as one of the major industries contributing to the economic growth of our country. However, nowadays they are also identified as the industry discharging heavy volumes of pollutants into water bodies and soil environment. These industries generate varieties of contaminants depending upon the manufacturing process. Especially, disposal of these industrial wastes to water streams and land sources remains a critical concern pertaining to the localities in their vicinity, wherein the aforesaid resources are vital for the healthy farming practices. The present work emphasizes on the study of affected agricultural soil structures in Sathyamangalam area, contaminated by the release of excess heavy metals from pulp and paper industrial effluents. Four soil samples were collected at specific seasons throughout the year (February to March, June to July, September to October and November to December) and estimated for the nutrients' levels as per the standard quality procedures, in order to assess the growth impact of seasonal crops cultivated. Dissimilarities in the uptake of primary and secondary nutrients were observed in the soil samples, there as on being low and high nutrient availabilities (against prescribed Indian Agricultural Standards for crop development) in Rabi and Kharif seasons, which shall be attributed to the rainfall, in turn promoting toxic leachates into the soil. The soil performances due to the percolation of industrial discharges reflected in the complexities of crop yields.

Keywords: Pulp and paper industries, Wastewaters, Soil, Crops, Seasons

1. Introduction

Environment is a primary concern and it plays a vital role in human health, society, plants, animals, and aquatic species. If there is imbalance created in any of these environmental factors, it changes the entire bio system, causing tremendous setback. Generally, environment gets deteriorated by the consumption of resources in an enormous volume by discharging huge unwanted toxic wastes. This consumption and wastage of resources in an unlimited manner pollutes air, water, land and soil. If any one sort of the pollution occurs then it continues as an association to form other kinds of pollution. Major reason for pollution is due to the establishment of industries in rural as well as in urban areas. Industries utilize water for their production. At the same time, large

amount of wastewater gets emitted from these industries¹.Treatment of these wastewaters is mandatory before discharge, however certain industries directly discharge the effluents into nearby water streams or land thereby contaminating the resources. Pulp and paper industry consume huge volumes of water and emanate wastewaters, mostly without proper discharge treatment, leading to an adverse impact on the environment, one of the major sources being aquatic pollution² which are fortified as toxic to the environment. The present work is focused on the impact created by the pulp and paper industry effluents in soil structures collected from the cultivable lands. Methodical investigations pertaining to the soil structure were analysed during four seasons of the year for the occurrence of varied nutrient levels and toxic metalions.

2. Experimental

Pulp and paper industries consume natural resources and energy in an alarming amount for its paper manufacturing processes. The conventional flow chart of paper making in pulp and paper industry is indicated in Fig.1. The prime requirement includes a source of cellulosic fibre containing materials, additives, chemical agents and water³.

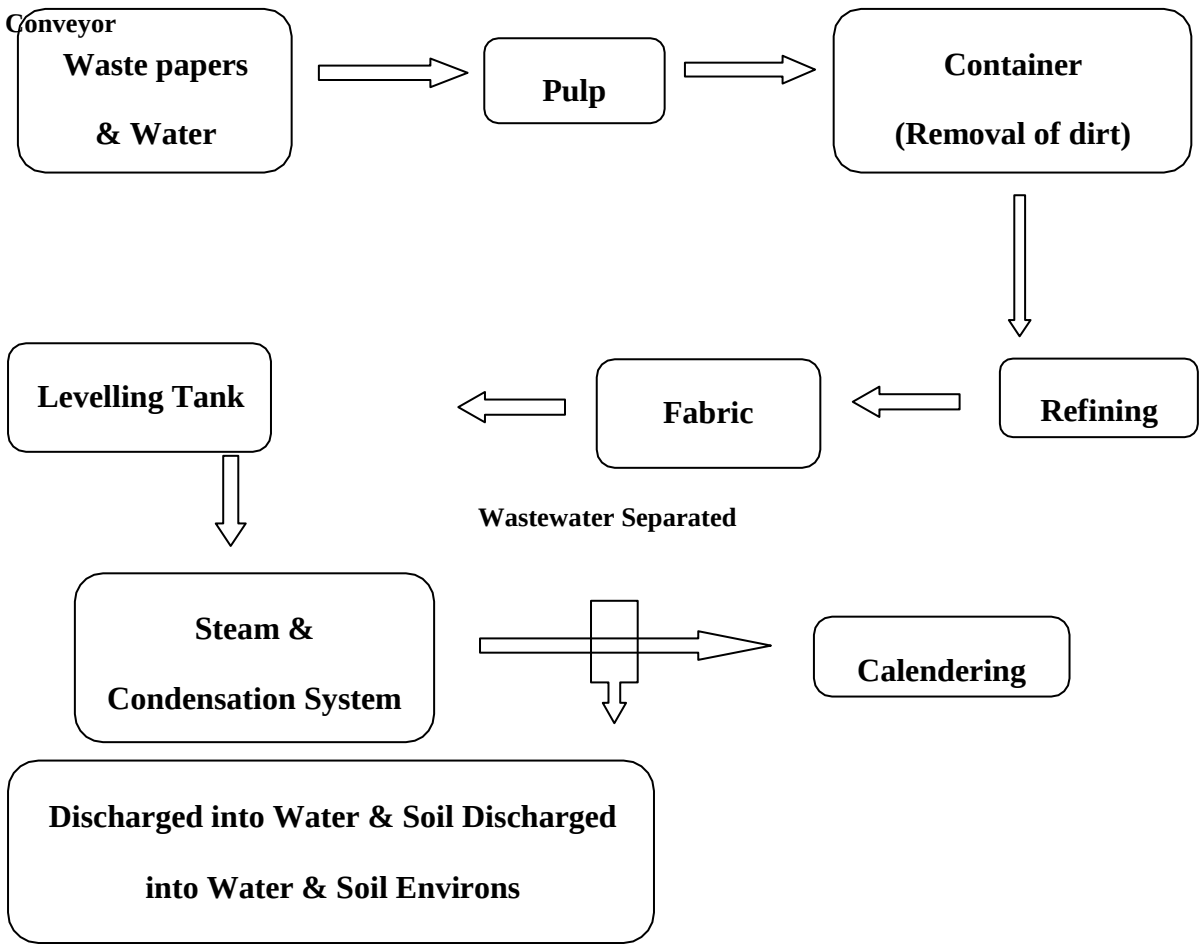


Fig 1 - Conventional flow chart
Cellulose is the fibre component of wood, a natural existence⁴. The wood materials are chipped well by

means of a chipper, which are digested with the chemicals and separated into fibre / lignin, the materials responsible for cellulose binding. The cellulosic sources are blended with water and impurities present in the mixture are removed by passing through screeners, then through the conveyor to form pulp like stuff. This mixture is blown out into a tank for cleaning and turning it into the form of pulp. The obtained pulp is subjected to refining process followed by addition of fabric like substances (agaltite / talc) and bleaching agents (calcium hypochlorite, sodium hypochlorite). The resulting mixture is allowed to be in levelling tank for few hours, passed to steam condensate system for moisture removal from the resultant. Finally, it is subjected to calendaring process, where paper products are obtained leaving behind the wastewaters, mostly discharged without proper treatment into nearby water and soil environments.

2.1 Emerging pollutants routes from Loams to HumanIntake

Soil, an upper cover of earth's surface is much important for human health in a number of ways. These are major source of nutrients, which are natural filters to remove contaminants from water. They possess well-developed structure, adequate organic content, and other properties that are helpful to sustain plant growth promoting improved yield⁵. Soil degradation, loss of soil structure and nutrient content, directly affects crop production and pose a threat to food safety⁶. This degradation in soil may be due to the presence of domestic wastes, agro waste, accrual of heavy metals, chemicals from industries, waste discharges reflecting a negative impact on human health and other living organisms. Farm practices with contaminated water sources have a viable chance to get exposed to heavy metals. Accumulation of heavy metals even in trace amounts while exceeding their tolerant limits, lead to many health disorders, such as cancers (arsenic), neurological damage, skin damage (lead, arsenic), kidney disease (lead, mercury, cadmium), skeletal and bone diseases (lead, cadmium)⁷. This accumulation of toxic metal ions by soils and its transport to plants is dependent on manyfactorssuchasmetalforms,soilstructureandthecropvariety.Uptakeofheavy metals by plants via soils tends to increase with metal concentrations. When the concentration becomes intolerable, the plant roots get injured because of low absorption capability, leading to pollution as a result of soil quality deterioration.

2.2 Choice of StudyRegion

Sathyamangalam region had been selected for assessing the agricultural soil contamination by the pulp and paper industry discharges and is represented in the map (Fig. 2). This region had been identified due to the presence of numerous small and large scale industries that are emitting wastewaters into the landsources.



Fig 2 - Study region (Sathyamangalam)

3.0 Material and Methods

Soil samples (I1, I2, I3, I4, I5, I6, I7, I8) from the environs of two pulp and paper industries, agricultural field samples (Fig 3) declared as contaminated by the aforesaid industrial effluents (A1, A2, A3, A4, A5, A6, A7, A8) were collected in the vicinity of Sathyamangalam region. Sampling was done in sterilized containers at a depth of 10 cm from the ground level during February - March, June - July, September - October and November - December. Evaluation of the contaminated samples was carried out to assess the occurrence of varied nutrient levels and heavy metal concentrations viz., pH, nitrogen (kjeldahl method), phosphorus (Olsen's method); potassium, sodium (Ammonium acetate); calcium, magnesium (EDTA method), sulphur (Sodium peroxide); zinc, chromium, lead, copper ions (Atomic Absorption Spectrometry) by analysing through digestion methods and absorption technique.

4.0 Results and Discussion

4.1 pH

pH plays a predominant quality control factor in soil samples. The recorded pH values for I1 and I2 samples collected during different seasons is indicative of alkaline nature, which shall be due to the excess bleaching additives in the second industry (I2, I4, I6, I8). However, Table 2 shows comparatively a noticeable change in the soil pH, lying within the prescribed standards. Seasonal changes in soil pH values are perceptible during pre-summer and spring seasons as per Tables 1 and 2.

4.2 Nutrients

Almost all the macro / micro nutrients and the heavy metal ions are found to be varied from the prescribed standard values for all the 16 samples analyzed. However, the variations in the registered values (Table 1, 2) amidst the samples, I1 – I8 and A1 – A8 during the seasons are detailed as follows:

N, P, K present in the soil samples act as “Primary Nutrients” for the plant growth. However, presence

of Ca, Mg and S are considered as “Secondary Nutrients”. Primary nutrients in the soil are much vital for the replenishment of soil nutrients. Nitrogen plays an important role in soil fertility. Phosphorus content of soil serves as a constituent of cell nucleus, essential for cell division and development of meristematic tissues at the growth points. Potassium, an indispensable constituent for the overall plant development, termed as “Quality nutrient” is an essential factor for several biological and chemical processes occurring in plants.

Table 1 - Parametric Analyses - Soil Samples - Pulp and Paper Industrial Area

S.No	Months	Sample	pH	Parameters										
IAS (Indian Agriculture Standards)			5.8-8.3	N	P	K	Na	Ca	Mg	S	Zn	Cr	Pb	Cu
				2.3 – 2.8 %	0.1 – 1 %	1.3 – 2 %	0.1 %	<1 %	< 0.5 %	0.5 %	300 – 600 mg/kg	400 mg/kg	250 – 500 mg/kg	135 – 270 mg/kg
1.	FEB – MAR	I1	8.36	1.18	0.11	0.38	0.20	9.88	4.56	0.02	52.0	65.4	12.1	61.5
		I2	9.15	1.77	0.10	0.54	0.71	8.90	3.29	0.02	52.4	64.0	20.4	67.0
2.	JUN – JUL	I3	6.85	1.40	0.54	0.42	0.34	8.13	3.96	0.04	51.8	67.1	13.3	64.0
		I4	7.82	1.16	0.36	0.66	0.32	8.08	4.10	0.02	52.3	65.7	16.0	64.8
3.	SEP – OCT	I5	7.33	1.62	0.66	0.48	0.31	8.24	5.14	0.04	52.6	66.2	17.1	67.0
		I6	8.52	1.22	0.41	0.71	0.34	8.21	5.24	0.03	52.9	67.4	18.0	68.0
4.	NOV – DEC	I7	8.35	1.30	0.42	0.55	0.36	9.12	5.44	0.04	54.4	69.8	22.0	69.2
		I8	8.60	1.24	0.43	0.47	0.36	8.45	4.31	0.03	53.4	61.8	21.0	69.4

Table 2 - Parametric Analyses - Soil Samples - Agricultural Area

S.No	Months	Sample	pH	Parameters										
IAS (Indian Agriculture Standards)			5.8-8.3	N	P	K	Na	Ca	Mg	S	Zn	Cr	Pb	Cu
				2.3 – 2.8 %	0.1 – 1 %	1.3 – 2 %	0.1 %	<1 %	< 0.5 %	0.5 %	300 – 600 mg/kg	400 mg/kg	250 – 500 mg/kg	135 – 270 mg/kg
1.	FEB – MAR	A1	6.54	1.32	0.50	0.35	0.31	8.08	0.39	0.04	42.4	363.3	11.2	165.3
		A2	7.36	1.71	0.38	0.49	0.32	7.94	0.38	0.03	41.8	365.6	13.0	168.8
2.	JUN – JUL	A3	8.21	1.69	0.56	0.37	0.09	9.61	4.48	0.04	42.4	460.4	14.2	167.4
		A4	6.95	1.22	0.35	0.51	0.04	8.70	4.31	0.06	42,2	370.7	11.0	169.5
3.	SEP – OCT	A5	7.59	1.36	0.52	0.35	0.32	8.46	4.41	0.04	43.4	369.6	18.4	169.0
		A6	7.48	1.22	0.42	0.52	0.36	7.98	4.40	0.03	52.6	468.9	8.8	169.2
4.	NOV – DEC	A7	8.23	1.42	0.38	0.31	0.24	8.54	0.41	0.04	42.8	364.0	8.9	151.1
		A8	7.55	1.30	0.47	0.49	0.25	8.38	0.40	0.03	43.4	265.4	11.0	159.8

Relative record of primary and secondary nutrients in industrial and agricultural soil samples reveals that, The nitrogen and phosphorus contents are observed to be comparatively higher in the agricultural soil samples(A1-A8) than their industrial counter parts(I1-I8)for the first two seasons and the last one. Similar results have been revealed during the irrigation of sugarcane crops using combined pulp and paper mill / ginning mill effluents^{8,9}. As far as potassium content is concerned, it is lesser in the agricultural samples than those mentioned in Table 1. Anomaly of nitrogen, phosphorus and potassium in the soil samples leave behind the leaves eventually turning brown, and retarded plant growth leading to chlorosis, as depicted in the image

(Fig.3).



Fig 3 - Image of affected Crops by Effluent discharge

Crop nutritional requirements depend on calcium, magnesium and sulphur concentrations. The existence of magnesium and sulphate ions is essential for plant metabolism^{10,11}.

Magnesium was observed to be higher in A3, A4, A5, A6 samples and sulphate ions was found to be lower from the prescribed standard. This may be due to leaching of the ions into the soil structures during rainy seasons, as it is highly soluble, being predominantly absorbed by plants. This process is reflected in the nutritional imbalance of the crops. Proper functioning of plant cell walls, membranes are ensured by calcium ions. Minimal calcium content is obvious in all seasons except the second one. This marked variation could be attributed to the fact of high levels of exchangeable sodium ion. Crop damage occurs when the sodium concentration is higher, resulting in poor yield. In the present study, sodium impact is greater during first and third seasons for A1 – A8 samples, in preference to I1- I8. This shows a marked inhibition in the photosynthetic processes^{12,13}

.4.3 Heavy Metals

Trace levels of heavy metal ions have been considered as crucial for the plant growth as it is evident from the lower limits of prescribed standard, below which the specific ions shall lead to deficiencies of themselves, affecting soil quality. Analyses of heavy metals viz., zinc, chromium, lead, copper imply that the concentrations of zinc and lead fails to fall within the permissible limits for I1 – I8 samples. However, their concentrations in A1 – A8 samples are found to be lower than standard values, in support of the zinc / lead deficiencies in those samples. Copper and chromium concentrations are found to be in excess for A1 – A8 samples than those of I1 – I8 samples, in lieu with Indian Agricultural Standards

The above implications for the total samples holds good invariably for all seasons. This disparity signifies to create their hazardous nature as biomagnification through food chain.

(Polluted water for irrigation of plants  Bioaccumulation in edible crops, Acute reflection of concentration in living organisms)

5. Conclusions

Soil quality parameters were analysed during the four seasons, according to standard operating procedures for the samples collected from Industrial and Agricultural region in Sathyamangalam, Tamil Nadu, India. Marked dissimilarities were noticed in the parameter values of the agricultural soil samples against their industrial precursors as per Indian Agricultural Standards. Several disparities reflected in the growth of the crop, evident from the leaves, as an indicative of the affected soil fertility. It is therefore concluded that the careless disposal of industrial wastes without proper pre-treatment should be curbed as it paves way to utmost contamination of the soils which in turn imply the insight of the risks associated with the environmental characteristics of soils.

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