Effect of Paper Mill Effluents on Accumulation of Heavy Metals in Coconut Trees near Nanjangud, Mysore District, Karnataka, India

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ABSTRACT / Physicochemical characteristics of wastewater from one of the paper mills near Nanjangud and the differential accumulation of heavy metals in parts of coconut trees growing in the area irrigated directly by the wastewaters of a paper mill were investigated. The total dissolved and suspended solids of wastewater were 1,136.9 mg/l and 2,185.4 mg/l, respectively. Biological oxygen demand (BOD) expands and COD is beyond the tolerance limit proposed by Indian standards. The concentrations of heavy metals like Cu, Pb, Zn, Ni, Co, and Cd in coconut water, root, and leaf are higher than the limits suggested by World Health Organization. Survival of coconut trees irrigated by polluted waters indicates tolerance to toxic heavy metals. Since coconut forms part of human food chain, accumulation of toxic heavy metals may lead to organic disorders.

Introduction

Trace elements play an important role in biological activities and, therefore, their deficiency or excess in human beings can lead to a number of disorders (Underwood 1971; Bowen 1972). Toxicity of elements like Co, Cd, Zn, Pb, Cu, and Ni has been very well brought out and documented by Casarett and Doull (1975) and Goyer and Mehlman (1977). Bioaccumulation of heavy metals in foodstuff plants has been discussed by Allen and Steinnes (1978), Shacklette and others (1980), and Somashekar (unpublished data) among others.

The problem of treatment and disposal of wastewater from paper mills industry is as old as the industry itself. With few exceptions, hundreds of paper mills in India release their effluents directly onto the agricultural lands, and the effluents are conveyed into fluvial systems or irrigation channels that subsequently would impose serious effects on the environment. One such case study has been investigated in the present report.

To know the extent of contamination in coconut trees by paper mill effluents, an area near a paper mill, 15 km south of Mysore, was selected for the present investigation. The paper mill discharges about 21,600 l of heavy-metal-rich wastewater per day. The wastewater produced and released by the factory drains directly into a coconut garden situated to the southwest, and the water so drained is used for the coconut plants, which are in various stages of yield.

Methodology

In the present study wastewater of the paper mill was sampled monthly from February to November 1988. Standard methods (APHA 1976) were used for the collection, preservation, and analysis of the samples. Roots, leaves, and coconut water samples of seven trees irrigated with wastewater from the paper mill and also from coconut trees irrigated by fresh water from a nearby area were collected (the randomly selected coconut trees from the garden were of different ages and yield potential). Soil samples from the same region were collected in polythene bags at monthly intervals. The plant samples were washed thoroughly with 0.5 N HCl and double-distilled water. To measure the heavy metal content of soils and plants, samples were oven dried at 70°C for 48 h. One gram of each sample was ashed for 6 h at 400°C, and then the samples were treated with AR grade HF and HNO_3 to incipient dryness. By adding 50% HCl, the mixture was heated until a homogeneous solution was obtained. Throughout the course of digestion, the samples were heated in a water bath at 75°C. Copper, Pb, Zn, Ni, Co, and Cd were analyzed by an AAS model IL 751 and induction-coupled plasma (ICP) spectrophotometer following the procedure described by Van Loon (1980). All other determinations were done by employing standard methods (APHA 1976). pH and Eh were estimated using a portable Biochem pH meter (model PM76) and portable Biochem conductivity meter (model C76).

Results and Discussion

The average values of the physicochemical characteristics of the effluents of the paper mill and unpolluted samples for a ten-month period (February–November 1988) are given in Table 1. The pH range observed was 8.2 and 7.27, which is a safe range (Ellis 1937; Roberts and others 1940; Klein 1973). The total dissolved and suspended solids in the effluents are 1,136.9 mg/l and 2,185.4 mg/l, respectively; in the unpolluted region, the water samples have a range of 37–193 mg/l. The BOD is 1,200 mg/l in the effluents, which is much higher than the tolerance limits (500 mg/l) for industrial effluents discharged on land for irrigation purposes [Indian Standard (IS): 3307, 1965]. A study of the factors of the physicochemical complex reveals that the wastewaters of the industry are highly alkaline, intensely turbid, often milky, may have a dark coloration, and are harmful when used for irrigation, as the heavy metal contents are very high.

Heavy metal content in the soil of the polluted and unpolluted areas and also comparative accumulation of trace metals in different parts of the coconut trees growing in polluted and unpolluted regions are given in Table 2. According to Duke (1970), the high concentration of heavy metals from coconut water is Cu = 4, Co = 0.01, Zn = 16, Ni = 1, and Pb = 0.015 mg/l, as against values obtained in this study (Table 2).

From Table 2, it is evident that metal concentrations of the coconut trees from the unpolluted region are considerably less when compared to those of polluted regions. The cobalt content of coconut water is comparable to that of the roots and leaves. The leaves contain higher concentrations of Pb and Zn than the roots, whereas the concentrations of Cu, Ni, and Cd in the roots are higher than in the leaves. The cobalt content of roots and leaves is not statistically significant. Similar differential accumulation is noted by Heydt (1977) in roots, stems, and leaves of different species of plants. The present investigation shows that the differential accumulation of heavy metals in different parts of the plant body is definitely not due to varying amounts of enrichments in the habitat of the sampling site (as seen through soil chemistry also), and therefore it might be due to the tendency of different parts of a plant to preferentially accumulate certain amounts of metals.

Shacklette and others (1980) are of the opinion that the available amounts of metals, rather than total amounts, determine the uptake of an element by a plant from the soil and that the available amount changes with the change in chemistry of environment.

Table 1. Average values of physicochemical characteristics of effluents and water samples from polluted and unpolluted areas (mg/l)

Sample	Characteristics	Effluents	Unpolluted water sample
1.	pH	8.2	7.27
2.	Temperature at site (°C)	31.4	28.6
3.	Conductivity (mhos)	1,132	229
4.	Total dissolved solids	1,136.9	193
5.	Total suspended solids	2,185.4	37
6.	Dissolved oxygen	3.7	6.8
7.	BOD for 5 days at 20°C	1,200	1.3
8.	Chemical oxygen demand	425	0.47
9.	Oil and grease	85.8	Trace
10.	Sodium	105.5	16
11.	Chloride	164.1	7.5
12.	Sulfates	85.7	2.32

In the present study, the pH value of the soil is 7.8; that of the effluents is 8.2, which is indicative of alkaline conditions. According to Whitton and Say (1975), the physicochemistry of metals, interactions with other metals, and the factors influencing the physiology of organisms determine the level of heavy metal uptake. Gibbs (1973) observed that the presence of metals in solution accounts for high percentage of uptake.

Taking into consideration the data in Table 2, it is clear that the accumulation rates of heavy metals are different for different parts of coconut palms (Fig. 1), and also they have tolerated 6 to 8 years of irrigation by the effluents, indicating the coconut palms' tolerance of heavy metal pollution. As suggested by Antonovics and others (1971), it may lead ultimately to the evolution of metal-tolerant varieties.

In the present study the concentrations of heavy metals in coconut water are higher than the limits prescribed by WHO (1971) for drinking water. Coconut water and kernel charged with elevated levels of toxic heavy metals pose a serious and potential health hazard and, if consumed over a long period of time, may even result in carcinogenic and mutagenic effects in humans (Goyer and Mehlman 1977). It is suggested therefore that irrigation of coconut palms with effluents charged with toxic heavy metals be avoided totally to prevent direct or indirect damage to biological communities.

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Table 2. Heavy metal concentration in coconut plant and soil samples[a]

Sample no. and description	Heavy metals (average, mg/l)					
	Cu	Pb	Zn	Ni	Co	Cd
1. Coconut water (polluted area)	10.42	7.45	5.56	6.21	2.16	3.97
2. Coconut water (unpolluted area)	3.84	0.24	2.69	0.16	0.1	0.02
3. Coconut root (polluted area)	25.5	12.32	19.7	21.8	1.92	28.3
4. Coconut root (unpolluted area)	6.21	2.6	7.93	1.16	0.42	3.1
5. Coconut leaf (polluted area)	15.7	17.62	25.14	10.49	1.32	13.57
6. Coconut leaf (unpolluted area)	7.32	1.24	8.79	0.86	0.27	0.13
7. Soils (polluted region)	14.0	31.00	23.7	26.00	22.5	24.8
8. Soils[a] (unpolluted region)	2.5	2.1	8.6	1.24	0.99	2.8

[a]Index for background or pre-industrial values.

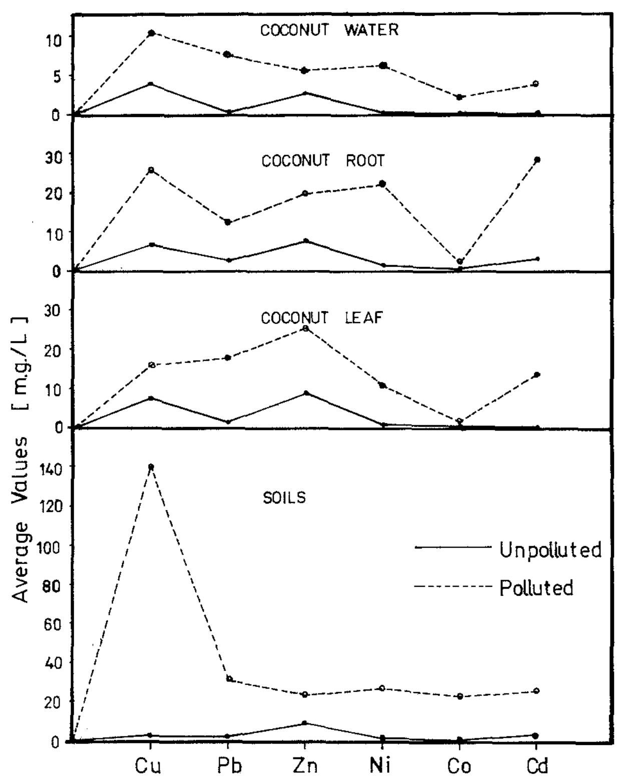

Figure 1. Heavy metal concentration in coconut plant and soil samples.

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