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SOIL POLLUTION BY HEAVY METALS FROM A BATTERY-MANUFACTURING COMPANY

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ABSTRACT: The concentrations of some heavy metals (Zn, Cd, Cu, Ni, and Pb) in soil samples at a battery-manufacturing company were determined by Atomic Absorption Spectrometry. It was found that the toxicity level of Zn, Cu and Ni was not exceeded while the concentrations of Cd and Pb were beyond the critical range above which toxicity can be said to occur. The Cd content had a mean of 15.7μg/g which is above the critical range of 3 to 8μg/g. The Pb content had a mean of 36242.6μg/g as compared to the critical range of 100 to 400μg/g in soil.

1. INTRODUCTION: Water and soil pollution due to ndustrialisation is a cosmopolitan problem creating acute insanitation as well as affecting the soil and crops. Plant and soil surfaces constitute the major sink for pollutants in the terrestrial environment and form the basis of food chains through which toxic substances may also be transmitted to man. The interception and retention of airborne particles by plants have been shown to depend upon the size, shape and surface texture of both the particles and the plant surfaces as well as on the ambient meteorological conditions.

Hazard to health and other detriments are defined with the implication that impurities below the level of detriment constitute mere contamination rather than pollution. How big a hazard is to human health, how much harm it causes to living resources, and how severe the damage it causes to amenities enables pollution to be proved */2/*.

The ions in the soil solution and in the solid phase that are of primary interest are those essential or toxic to life and those important to soil development. Most of the ions involved in soil development are also essential for plants and animals. Elements such as Li, Be, Ni, Cd, Hg, Al and Pb, are toxic to life above typical natural concentrations, and are of questionable value at any concentration. Fixing the threshold concentration at which a substance is toxic is extremely difficult because toxicity varies with maturity and general health of the organisms, with the presence and concentrations of other ions and with the species and variety of the organism.

Chemical compounds introduced into soils can be adsorbed by soil constituents. The extent of adsorption or degradation does not only depend on the properties of the chemical but also on the properties of the site */3/*. Soils differ greatly in their susceptibility to chemical pollution. Accumulation of the chemical compounds entering the soil depends on such soil properties as texture, humus content, pH, exchange capacity, and is directly related to the water regime.

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Studies on the uptake of arsenic in soil and plant [4] showed that it resulted in phytotoxicity, and the element becomes hazardous to mankind. The presence and level of metal contamination in Northern Ontario showed that soil contamination is extensive [5] and that high level of nickel was found up to 3 miles from a smelter region, toxic water-soluble nickel levels were found up to 10 miles, while excessive levels of smelted materials were found in a vegetation close to the smelter.

It has also been shown that composts from municipal wastes contain large amounts of heavy metals and polycyclic aromatic compounds [6] and that the danger created by long-term application of these wastes consists not only in accumulation of heavy metals or polycyclic compounds in the soils but in the accumulation of toxic levels of these compounds in plants. The accumulation of cadmium in plant tissue is influenced by the level of cadmium available in the soil in which the plants are grown [7]. The dry matter yield of the plant grown under a high concentration of cadmium was slightly decreased [8].

The objective of this work was to determine to what extent the threshold value of heavy metals in the soil is exceeded by a typical industry producing automobile batteries. This should give an indication of the extent to which the soil constitutes a potential danger to neighboring residents.

2.0 EXPERIMENTAL

2.1 Sampling: Soil samples were collected within the premises of a battery manufacturing company. Random sampling was done with an auger from 0 to 15cm depth of the soil. Five different soil samples were collected at different locations in the industry ranging from the administrative block (S1), bag house (S2), battery-breaking centre (S3), slag yard (S4), and scrap yard (S5). These samples were air-dried for seven days, ground and sieved to remove organic debris and large mineral particles. The sieved sample, each, was thoroughly mixed and then stored in a well labelled polythene bag for subsequent analysis. [9].

2.2 Sample Preparation: Kuklin [10] proposed a rapid extraction method which involves heating the soil with 1M-HNO_3 (10 vol) for 1 hour. Hot HNO_3 extracted 60 to 70% of the Cu, Zn and Cd from an uncontaminated soil and 90 to 100% from a contaminated soil.

The sample was prepared for Atomic Absorption Spectrophotometry (A.A.S) by the Kuklin method of extraction with slight modification. 1g of each soil sample was extracted by shaking with 50ml of 1M HNO_3 in a plastic bottle. on a mechanical shaker for 4 hours. The solution was centrifuged at 1200g for 15 minutes. The supernatant was collected and the concentrations of the metals in the extract were determined.

3. RESULTS AND DISCUSSION: Table1 shows the concentration of the heavy metals (Zn, Cd, Cu, Ni, Pb) in the soil samples (S1 - S5), while Table 2 expresses the percentage of the concentration relative to each spot considered. The mean concentration of Zn in the soil (160.45µg/g) is within the critical concentration range (C.C.R.) of 70 to 400µg/g as shown in Table 3. This indicates that Zn did not pollute the soil sampled. Fig. 1. illustrates the concentration of Zn in the soil samples. Similarly CU and Ni with mean concentrations of 64.8µg/g and 48.7µg/g respectively occurred below their critical concentration levels of 60 to 125µg/g and 100µg/g. Hence, they too did not pollute the soil sampled. These are shown in Fig. 3 and 4. Pb occurred as a major pollutant in the soil samples as shown in Fig. 5. Its concentration was above the critical concentration range.

Cd also existed as a pollutant in the soil samples S2, S4, and S5 while it did not constitute any

Table 1: Concentration of Heavy Metals in the Soil At Different Spots in the Factory (µg/g)

Soil Sample	Zn	Cd	Cu	Ni	Pb
S1	134.75	7.49	60.2	79.2	22301.43
S2	107.16	21.77	35.86	35.1	23849.68
S3	93.48	7.47	69.54	31.15	51538.68
S4	166.74	17.52	35.60	39.06	20159.67
S5	300.18	24.26	122.63	58.84	63363.32
Mean	160.45	15.7	64.8	48.7	36242.6

Table 2: Level of Heavy Metals Expressed as Percentage

Soil Sample	Zn	Cd	Cu	Ni	Pb
S1	16.80	9.84	18.59	32.55	12.31
S2	13.36	27.73	11.07	14.42	13.16
S3	11.65	9.51	21.47	12.80	28.44
S4	20.78	22.32	10.99	16.05	11.12
S5	37.41	30.90	37.87	24.18	34.97

Table 3 Critical Concentration of Heavy Metals in Soil [11]

Metal	Critical Concentration Ranges (µg/g)
Zn	70 - 400
Cd	3 - 8
Cu	60 - 125
Ni	100
Pb	100 - 400

Critical range is the range of values above with toxicity is considered to be possible.

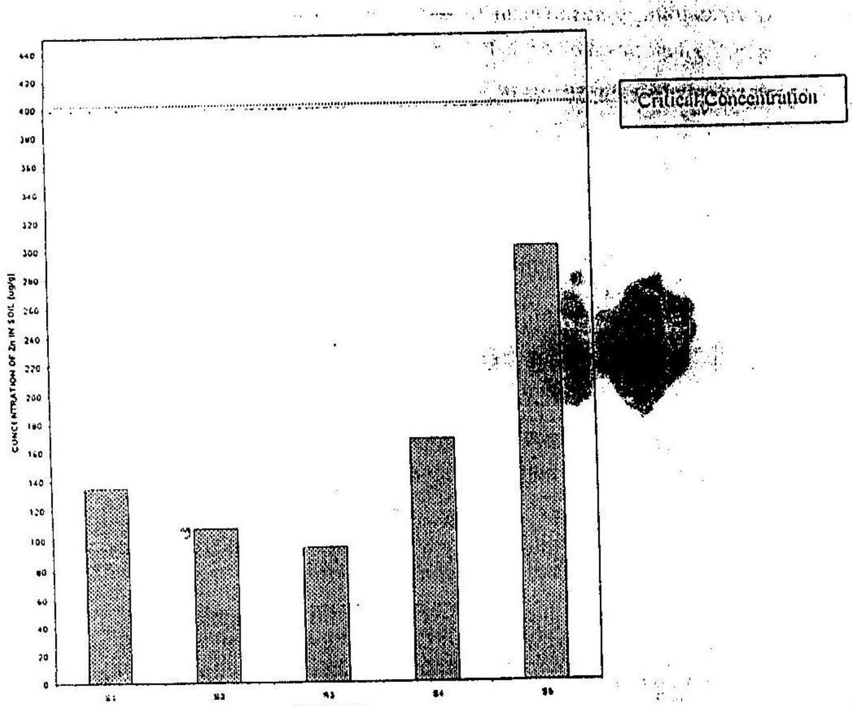

FIG 1:CONCENTRATION OF ZINC AGAINST SOIL SAMPLES

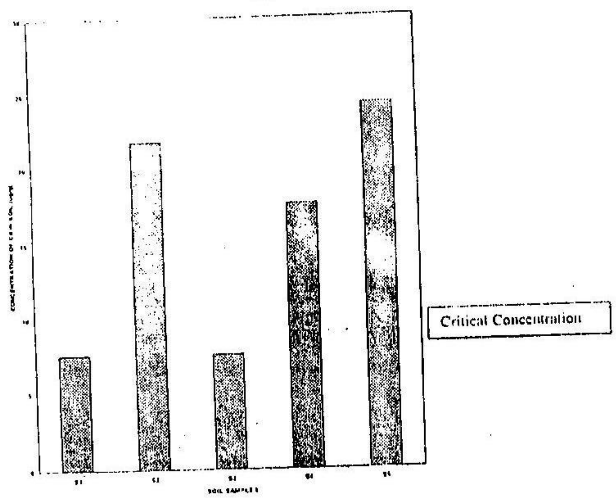

FIG 2 CONCENTRATION OF CADMIUM AGAINST SOIL SAMPLES

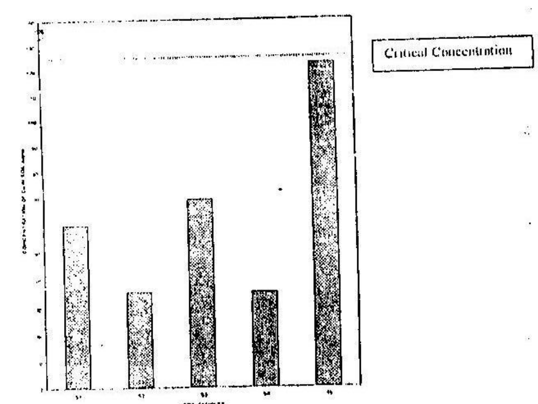

FIG 3 CONCENTRATION OF COPPER AGAINST SOIL SAMPLES

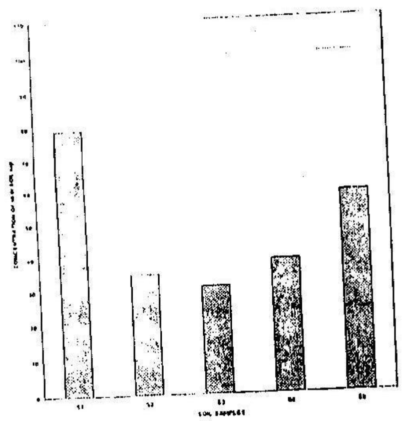

FIG 4 CONCENTRATION OF NICKEL AGAINST SOIL SAMPLES

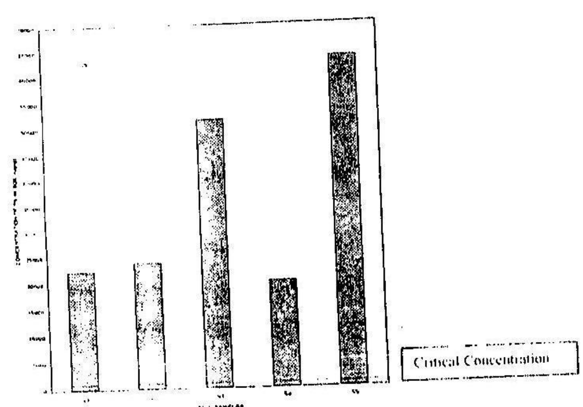

FIG 5 CONCENTRATION OF LEAD AGAINST SOIL SAMPLES

source of pollution in samples S1 and S3. However Its mean concentration (15.7μg/g) was above the critical concentration range as shown in Table 3. This is illustrated in Fig. 2.

4. CONCLUSIONS: From the results of this study, it is clear that lead and cadmium are the only sources of pollution in the soil of the battery-producing company. This supports the fact that the major raw materials used in battery manufacturing are lead and cadmium.

REFERENCES:

1. Little, P. (1977). Deposition of 2.75, 5.0 and 8.5cm particles to plant and soil surfaces. Environmental Pollution 12, 293-305.
2. Harrison, R.M. (1990). Pollution: Causes, Effect and Control. 2nd Edition, Royal Society of Chemistry.
3. Blume, H.P, Litz, N. and Doring, H.W. (1983). Adsorption, percolation and decomposition. Method for forecasting the behaviour of organic chemicals in soils. Ecotoxicology and Environmental Safety 7, 204 - 214.
4. Acssympser, G. (1975). Behaviour and phytotoxicity of inorganic arsenical in soil. Arsenical Pesticides Sym. 7, 35-37.
5. Costescu, L.M. and Hutchinson, T.C, (1972).Ecological consequencies of soil pollution by metallic dust from the sudbury smelters. Ins. Environ. Sci. Tech. Meet. Proc. 18, 540 -545.
6. Vanlaerhoven, C. J. (1973). Addition of organic fertilizer to soil. Bodenkultur 24, 237 - 252.
7. Alloway, B.J (1990). Trace Metal in Soils. Blackie and Sons Ltd. Glasgow U.K. pp 100 - 124.
8. Schlichting (1978). Funktion Von Boden in der Okosphare. Dat Dokum. Umweltshuiz (umwettagung) Hohenheim 22, 9 - 12.
9. M. G. Keizer, V. J. G. Houba and T. M. Lexmond (1984). Sampling of Soil and Plant Material for Chemical Analysis Syllabus.
10. Kuklin, Yu. S (1980). Comparative evalution of differential methods for extraction of Cu, Zn, Cd from soil. Pochvoedenie 10, 122 - 124.
11. B.J. Alloway (1990). Heavy Metals in Soils. John Wiley and Sons Inc. New York. 323 pp.