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Effect of Orange Peels Adsorbent on the Performance of Soil Aquifer Treatment (SAT)

Divya S.J.[1], Nagarajappa D.P [2], Manjunath N.T.[3], Shiva Keshava Kumar P.[4]

PG Student, Department of Civil Engineering, UBDT College of Engineering, Davangere, Karnataka, India.[1]

Professor, Department of Civil Engineering, UBDT College of Engineering, Davangere, Karnataka, India.[2]

Professor & Director, Center for Environmental Science Engineering & Technology, University UBDT College of Engineering, Davangere, Karnataka, India.[3]

Professor & HOD, Department of Civil Engineering, Jain Institute of Technology, Davangere, Karnataka, India.[4]

ABSTRACT: Orange peels powder was used to enhance the removal efficiency of Soil Aquifer System (SAT) for the removal of Copper and Zinc. The bench scale studies were carried out using 4 different concentrations of both metals in water (5, 10, 15, 20 mg/l) and varying adsorbent heights (25%,50%,75%) in 1.0m soil depth. Soil properties were determined and silty sand soil was used. The efficiency of SAT to remove Cu and Zn without orange peels resulted in 40.8%, 42.2%, 41.93%, 40.43% for Cu and 38.8%, 38%, 36.2%, 37.1% for Zn respectively. The adjunction of orange peels in SAT resulted in increased removal efficiency. While the efficiency was observed maximum at 50% height of adsorbent resulting in 85.8%, 84.2%, 79.8% and 81.3% for Cu and 62.8%, 52.4%, 55.46%, 58.75% for Zn. Comparison studies show that SAT in conjunction with orange peels showed better performance than without adsorbent one.

KEYWORDS: Soil Aquifer Treatment, Synthetic water, Orange peels powder, Copper, Zinc.

I. INTRODUCTION

Water of high quality is essential to human life and water of acceptable quality is essential for agriculture, industrial, domestic and commercial uses. All these activities are also responsible for polluting the water. The constant blending of heavy metals from industrial effluents by activities like mining, metal processing, electro plating, etc., to water stream induces various unfavourable effects on human health and the environment. Toxic metals tend to bio accumulate by entering into the food chain [1]. Elimination of toxic heavy metals from industrial wastewater has been done by several conventional methods like electro precipitation, membrane separation, evaporation, ion exchange, etc., which are expensive and inefficient for low concentrations of heavy metals. Novel technologies in treatment of industrial wastewater for reuse have been elaborated. Soil Aquifer Treatment (SAT) is one of the techniques with high infiltration system. Numerous studies have established positive and effective results for treatment of wastewater by SAT [2].

Copper and zinc are toxic heavy metals dismissed into the environment by the industrial activities, anthropogenic actions etc., Heavy metals are non-biodegradable unlike other organic pollutants. Copper and zinc are widely used in metal industries like mining, metal cleaning, plating baths, pulp and paper mills, fertilizers, refineries, etc., which produce high levels of copper and zinc in effluents. Even though copper and zinc are vital for human health, excess amounts can become hazardous to the body [3][7].
Copper has limits of maximum acceptable concentration as 1.5 mg/l in drinking water. Excess quantities of copper can lead to issues like nausea, haemolytic anemia, gastrointestinal bleeding, headache, respiratory problems, damage kidney and liver and even death [3].

Zinc is also a vital element important for human health like to prevent premature skin aging and muscles. But too much of Zinc ingestion about 225 mg can cause eminent health issues like stomach cramps, vomiting, nausea, skin irritations, etc.,[4]

The removal efficiency of low cost adsorbents can be tested in aqueous solutions and then study in large scale. One of such easily available and inexpensive adsorbent is waste orange peels. The vast amount of orange peels adjudges for the feasibility of choosing it as adsorbent for the study. Orange peel mainly constitutes of hemi-cellulose, cellulose, pectin substances, chlorophyll pigments and other low molecular weight compounds like limestone, etc., Hydroxyl and carboxyl are the functional groups of cellulose which are active binding sites for metals, chemical modification with Nitric acid enhances cation exchange capacity by increasing functional groups [5].

This study infuses SAT with orange peels to remove heavy metals as it is always preferred to aim at working with low cost process. Various authors have contributed studies to this method and shown positive results which prove that wastewater can be effectively renovated by SAT. Following papers are typically reviewed.

II. RELATED WORK

Pilot scale studies were conducted by Nema P.et al. [6] for the treatment of primary effluent by Soil Aquifer Treatment(SAT) system. They found that 90% of organic pollutants, nutrients along with bacteria and viruses were effectively removed. Chunye Lin et al. [7] studied the heavy metal retention on multi-sorbents in SAT and inferred 32% of soil accumulated copper metal and 51.6% of Zinc accumulation into oxide and carbonate components respectively of the multi-sorbents. Mahmoud A. et al. [8] made a study on recharging plant effluent into the ground water and designed a optimum pilot plant for SAT in the site. Essandoh H.M.K et al. [9] conducted experiments on saturated laboratory column to stimulate SAT and found effective removal of chemical and biological oxygen demand, dissolved organic carbon and other pollutants. They found that high permeability soils would achieve better removal performance. Peter Dillon et al. [2] explained the role of SAT in water reuse which explained the role, value, limitations and policy requirements for aquifers in indirect usage. Further the authors are of perspective that performance of SAT is site specific and depend on water hydrogeology, type of soil, wastewater quality, etc.,

Xiaomin Li et al. [4] studied the biosorption behaviours of zinc and other metal on to chemically modified orange peels. The maximum adsorption capacity of Zinc was found to be 1.2*mol/kg* which was increased by 60% compared to raw orange peels. Ningchuan Feng et al. [5] made adsorption studies of copper(II) on modified orange peel and this proposed method was applied to electroplating wastewater and results of 97.1% of copper removal from 0.250g adsorbent dose were obtained.

The following objectives were addressed by this study. The objectives of this project are to compare the efficiency of the selected soil to remove Cu and Zn with and without adsorbent in SAT system. Besides, the present study also aimed at behaviour of soil with different adsorbent height.

III. METHODOLOGY

A. Adsorbent Preparation

Orange peels were segregated locally, dried and pulverized. Then, it was acid digested using 4N HNO_3 and heated for nearly 90 min in hot water and washed several times with water to remove acid. Later the peels were dried in oven at 120^o C for 4 hours. It was then powdered and sieved to two uniform constant particle sizes viz. 90 and 150 μ according to grain size distribution. The powder thus obtained was used as adsorbent.

B. Preparation of Metal Solution (Synthetic water)

Analytical grade reagents were used for preparing the synthetic water. Cu^{2++} and Zn^{2++} solutions were prepared by diluting merck grade stock solutions with deionised water to a desired concentration. Concentrated solutions of Copper

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and Zinc Sulphates were prepared by dissolving the compounds. The solutions were then diluted to different known concentrations viz. 5,10,15 and 20 mg/l for testing performance of SAT system. They were prepared and filled in 20 litres influent tank.

C. Preparation of Soil

Silty sand was characterized by the geotechnical properties obtained by the experiments. The dry density of soil was found to be 1.64 g/cm^3 and it was maintained by mixing water and compaction. Experiments were carried for single depth of soil 1m and 3 heights of adsorbent. A layer of 10 cm adsorbent was introduced in the soil column at 25% 50% and 75 % in different trials and experimented. A Nearly neutral *pH* 7.2 was observed in the soil.

D. Experimentation

Column studies were conducted in PVC columns of 5 inch diameter and 1.5m length. Silty sand was used for SAT and filled upto 1m depth. When conducting experiment with adsorbent, 3 adsorbent heights were tried at 25%, 50% and 75% of 1m soil depth. Synthetic water to be tested for removal efficiency was passed through the overhead tank and a ponding depth of 30cm was maintained above the soil mass. The effluent sample was collected from the bottom of the column and the metal concentrations were tested using Atomic Absorption Spectrophotometer(AAS). For each predetermined condition of experimentation, the soil was filled afresh in the column. Effluent samples in duplicate were prepared and analyzed for metal concentration using AAS.

IV. Result and Analysis

A. Performance of Silty Sandy soil without orange peels adsorbent

Table 1. Shows the performance of silty sand soil of depth 1.0m without adsorbents. Table 1 also indicates that silty sand performed better for removal of Copper than for Zinc.

Table 1. Performance of SAT System Without Adsorbent for Column Soil Depth 1.0m in Silty Sand

Sl no	Parameter	Silty sand		
		Influent Characteristics (mg/l)	Effluent characteristics (mg/l)	Removal efficiency (mg/l)
1	Copper	5	2.84	43.20
2		10	5.26	47.40
3		15	8.24	45.05
4		20	10.61	46.90
5	Zinc	5	3.06	38.8
6		10	5.79	42.1
7		15	8.87	40.8
8		20	12.58	37.1

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Table 1 predicts the performance of SAT system without any adsorbents. The silty sand soil used performed better for removing Copper than Zinc. It was recorded that silty sand removed maximum copper from 10mg/l influent which is 47.4% removal efficiency. The values were recorded at optimum value which were calculated by saturation studies. The least removal was 43.2% which is not much significant. Hence average values can be taken for consideration for different influent concentration. Overall average performance of SAT for copper removal is 45.6% and for zinc is 39.7% in without adsorbent case.

B. Performance of Silty sandy soil with orange peels adsorbent at 25%, 50%, 75% of 1.0m depth soil

The column studies was carried out with different Copper and Zinc influent concentrations from 5 mg/l to 20 mg/l with a difference of 5mg/l. Statistically, silty sand showed higher performance for copper than zinc but with orange peels also proved to show better performance for copper but the efficiency was much more enhanced in the latter case. The performances of SAT with orange peel at different heights of the column are summarized in figures below.

Fig.1 shows optimum removal of Copper and Zinc at 25% adsorbent height for influent concentrations of 5, 11, 15 and 20 mg/l. Copper removal efficiency were found to be 80.4%, 82.7%, 78.4%, 77.85% respectively for influent concentrations mentioned. Similarly Zinc removal efficiencies were obtained as 49.8%, 53.9%, 50.9% and 50.65% respectively. Maximum removal efficiency at 25% height of adsorbent for copper is 82.7% for influent concentration of 15 mg/l which is comparatively much lower for zinc found as 53.9% for 10 mg/l.

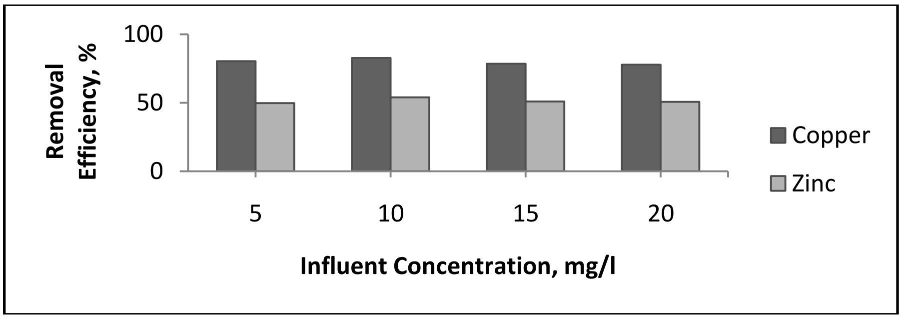

Fig.1. Removal Efficiencies for *Cu* and *Zn* for Silty Sand Soil with Orange Peels Adsorbent at 25% height.

Fig.2 depicts the removal of Copper and Zinc at 50% adsorbent height for influent concentrations of 5, 11, 15 and 20 mg/l. Removal efficiency of Copper was found to be 85.8%, 84.2%, 79.8%, 81.3% respectively for influent concentrations mentioned. Similarly zinc removal efficiencies were obtained as 62.8%, 52.4%, 55.46% and 58.75% respectively. Maximum removal efficiency at 50% height of adsorbent for copper is 85.8% for influent concentration of 5 mg/l which is comparatively much lower for zinc found as 62.8% for 5mg/l.

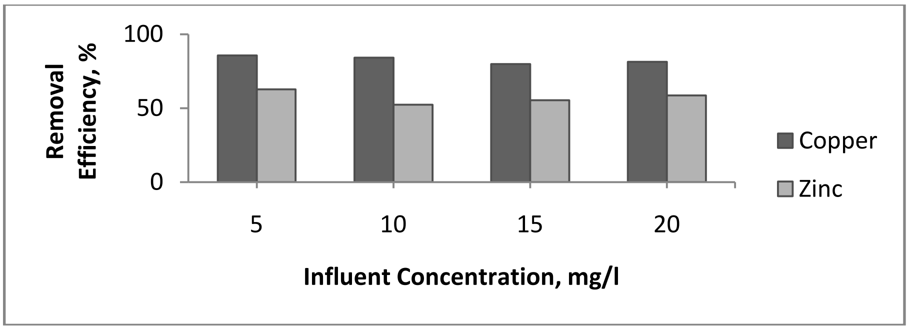

Fig.2. Removal Efficiencies for *Cu* and *Zn* for Silty Sand Soil with Orange Peels Adsorbent at 50% height.

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Fig.3 depicts the removal of Copper and Zinc at 75% adsorbent height for influent concentrations of 5, 11, 15 and 20 mg/l. Removal efficiency of Copper was found to be 79.0%, 83.7%, 77.4%, 80.7% respectively for influent concentrations mentioned. Similarly zinc removal efficiency were obtained as 48.4%, 51.4%, 51.0% and 49.3% respectively. Maximum removal efficiency at 75% height of adsorbent for copper is 83.7% for influent concentration of 10 mg/l which is comparatively much lower for zinc found as 51.4% for 10mg/l.

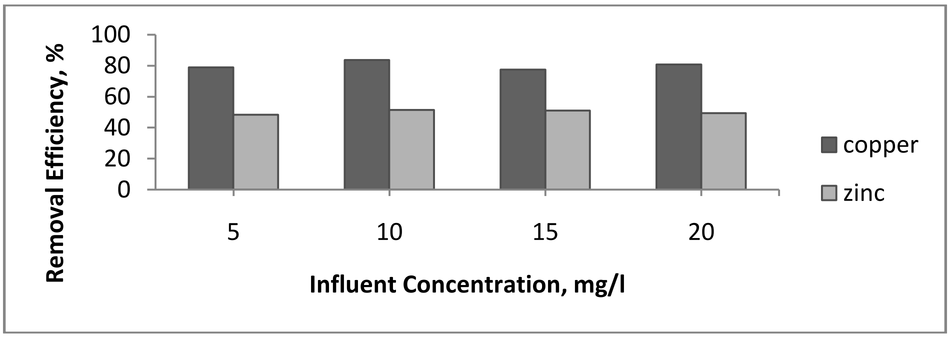

Fig.3. Removal Efficiencies for *Cu* and *Zn* for Silty Sand Soil with Orange Peels Adsorbent at 75% height.

The study of results shows that there is no significant change in removal efficiency for both metals for different influent concentrations i.e., 5,10,15,20 mg/l. This constant removal can be studied for further increased concentrations of influent. Though maximum efficiency was attained in the 50% height of orange peels. Fig.4. shows the comparison of performance of SAT for Cu and Zn removal without adsorbent and adsorbent at 50% height. From the statistics, copper is removed effectively by silty soil than Zinc which in turn is drastically increased by combining it with orange peels in almost middle of the soil layer in the SAT system.

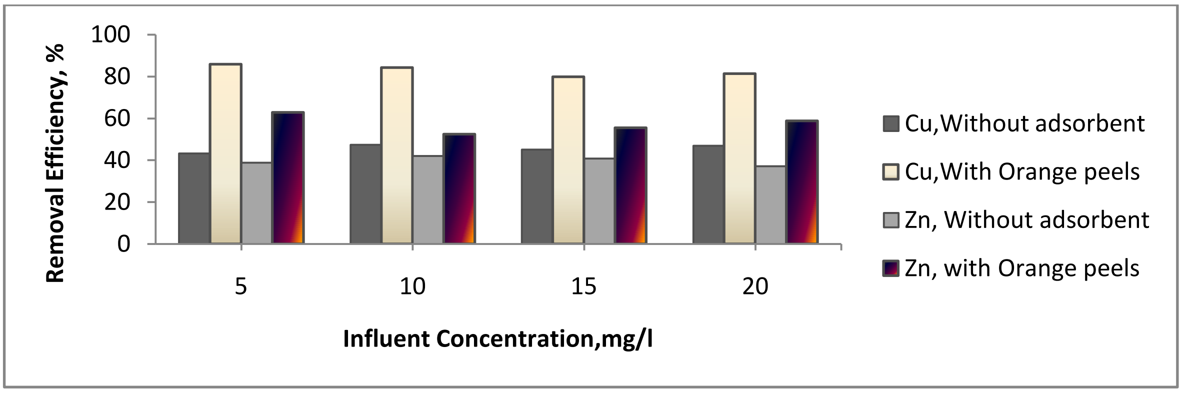

Fig.4. Comparison of removal of Copper and Zinc by SAT without and with adsorbent (at 50% height).

C. Removal Efficiency of Copper

The results speak copper removal trend by SAT for different influent concentrations which indicate almost similar removal efficiencies. This trend was found in without adsorbent as well as with adsorbent case. Albeit orange peels are found to increase the efficiency of SAT by 39% which is commendable. Silty sand soil is more effective in removing copper.

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B. Removal Efficiency of Zinc

Zinc removal efficiency by SAT is also similar to copper trend in uniformity but tend to be lower values. This indicates silty sandy soil is not very effective for zinc as for copper. Only 20% in average efficiency was increased by combining with orange peels. But still it is a advantage as it increased the removal.

V. CONCLUSION

The experimental studies reveal that silty sandy soil enhanced its removal efficiency of Copper and Zinc by the integration of orange peels as adsorbent in between the soil column. Almost constant removal efficiency was found for different influent concentrations. Albeit removal efficiency was achieved maximum in the adsorbent placement height 50% of 1.0m soil mass. Silty sandy soil can be merged with orange peels and used to treat copper polluted effluents more effectively. The maximum removal efficiency of this SAT system for Copper is 85.8% and for Zinc is 62.8 at 50% height of adsorbent placed. The metal concentrations reached admissible values after treating. All the results can be utilized for further increased concentration studies.

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