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DETERMINATION OF THE COST-EFFECTIVE ADSORBENTS TO REMOVE TOXIC METAL POLLUTANTS FROM INDUSTRIAL WASTE WATER

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ABSTRACT

Pollution in any form affects our environment dead fully. As an economist, the best act would be to select the relief measures which are cheap, best and natural way of removing the pollutant before it enters of life cycle. Even if it cannot be prevented from being released, it can be avoided before it enters the natural medium. Industrial effluents from all different scales of industries are causing pollution. The most toxic pollutants are considered for the present study- Arsenic, Chromium and Lead. The relief measures which could be utilized by the industries (polluter) themselves, before determined. And more specifically for each zone of the country, the cost- effective adsorbents are suggested after having reviewed quantitative and rapid removal capacity of toxic pollutant. A broader picture could also be considered of which adsorbents is best suited for which country in the world, depending on the ready availability and efficiency of its removal capacity.

Keywords: Adsorbent, Economic, Efficient, Arsenic, Lead, Chromium, Pollutant

1.0 INTRODUCTION

"Water water everywhere not any drop to drink." These words by S.T. Coleridge are surprisingly appropriate for the current world water crisis. The availability and quality of water always has always played an important part in determining not only where people can live, but also their quality of life. Even though there always has been plenty of fresh water on Earth, water has not always been available when and where it is needed, nor is it always of suitable quality for all uses. Generally two types of water resources are used for water supply:

Surface water: such as Ponds and lakes, Streams and rivers, Storage reservoirs, and Oceans, generally not used for water supplies, at present.

Sub-surface: sources or an underground source includes springs, Infiltration wells, and Wells and Tube-wells.

The lack of clean water has always been an issue of environmental concern all over the world. The majority of pollutants are sewage and industrial waste water which is produced and discharged into river and lake. Domestic sewage refers to waste water that is discarded from households. Also referred to as sanitary sewage, such water contains a wide variety of dissolved and suspended impurities. Generally, water is polluted by four kinds of sources.

1. Traditional organic waste
2. Generated from industrial process
3. Chemical agents (for fertilizer, pesticides)
4. Silt from degraded catchments

The widespread industrial pollution was generated rapidly in the 1800's with the start of industrial revolution. This resulted in the swift increase in the amount of industries being started, which proportionally accelerated the industrial pollution to the environment on the other side. There are number of forms of industrial pollution such as air pollution, water pollution, noise pollution, chemical pollution, land pollution generated by industries. One of the most common is water pollution, caused by dumping of industrial waste into waterways, or improper containment of waste, which causes leakage into groundwater and waterways. It is estimated that 15% of world-wide water is used for industrial purpose. While it is estimated that three-fourths by volume of waste water generated is from industrial waste. The major pollutants are coming from large and medium industries. The Environmental Protective Agency estimates that up to 50% of the nation's pollution is caused by industry. Because of its size and scope, industrial pollution is a serious problem for the entire planet, especially in nations which are rapidly industrializing. Nowadays the environmental issue is mainly stressed in developing countries. During the last fifty years, the amount of industries in India has grown rapidly. The main sources of water pollution are industrial chemical waste, organic, and thermal wastes. Industrial pollutants, such as wastes from chemical plants, are often dumped

directly into waterways. Oils and salts are washed off city streets. Heavy metals and organic chlorides are leached from industrial dump sites.

1.2 PROBLEMS OF WASTE WATER

Industrial pollution hurts the environment in a range of ways, and it has a negative impact on human lives and health. The chemical industry creates an increasing quantity of substances every year, adversely affecting the essential aspects of the composition of the atmosphere, soil and water. In the industrially high dense areas, in addition to the effects on local health and impact on nature, the damage to the social and economic functions of the environment. The industrial activities polluted the water streams especially rivers and loss it potential value and beneficial use. The waste includes the toxic materials which flow into the river and seas which when go underwater emits certain poisonous chemicals and which pollutes the water in the oceans. When this dirty water goes into the lungs of sea animals, it creates negative implications; animals are highly affected which is the main causes the death of many marine livings. Industrial waste is directly released into the nearby lake because of which the lake water becomes with toxic metals; some of the effluents reach directly to the underground. So that ground water in the industrial areas is unfit even for agriculture. Critical sources of drinking water such as river, lake and underground aquifers have been increasingly threatened by industrial pollution. This polluted water enters into the human life also as water is the major source of households. People consume the water for drinking water, cooking, washing and other household activities. By this way industrial pollution have impact on human health. So there is a serious problem for developing countries.

1.3 OBJECTIVES

These above causes have inspired to think over the present research work with the following objectives

- An extensive literature is available on the varying capacity of different type of adsorbents to adsorb different toxic metal ions from water medium especially from the industrial effluents. A part of this dissertation work will be to review this literature and choose the cost-effective adsorbent for each toxic metal ion selected for the present study.
- The selection of the cheap and easily available adsorbent with efficient adsorbing capacity will be carried out for each metal ion and would specify also about which adsorbent is best for being applied in Indian conditions.
- More specific results on which adsorbent is suitable for being applied in each region of India depending on the availability of adsorbent and the major polluting metal source of that particular region.
- The study also aims at highlighting the effects of wastewater pollution towards the environment and the society (such as health factors, agriculture, economic impacts, etc) and how it influences the economic factors.
- This study is also an enquiry into the determination of the cheap and efficient adsorbents for three major toxic heavy metals: arsenic, chromium and lead, which are present in large quantity in the industrial effluents.

2.0 METHODOLOGY

From the literature available on the removal performance and cost-effectiveness of various low-cost adsorbents derived from agricultural waste, industrial by-products, or by natural material and activated carbon, were evaluated and compared for its efficiency in removing the heavy metals arsenic, chromium, lead from metals-contaminated wastewater. The few agriculture wastes being used as adsorbent for the removal of toxic metal removal process are sugarcane bagasse, rice husk, oil palm shell, coconut shell, tea leaves, coconut husk etc. To alleviate these problem of removing metals from water medium efficient waste water treatment method are available.

Depending on the forces, mainly there are two types of adsorption.

1) Physical adsorption: adsorbents derived from agricultural waste
2) Chemical adsorption: industrial by-product

Industrial by-products include activated carbon generated from different sources. Technical applicability and cost-effectiveness are the key factors that play major role in the selection of the most suitable cost-effective adsorbent to remove the toxic heavy metal from the industrial wastewater effluent. Our main aim in the present dissertation is to choose best possible adsorbents for the toxic metal of concern which are generated from agricultural waste.

3.0 TOXIC POLLUTANTS

Heavy metals represent common type of chemical pollution in water. The waste water released coming from the industries is termed as "industrial effluent" which contains toxic substances especially heavy metals. The presence of heavy metals in the environment is of major concern because of their toxicity; it contains the heavy metals like arsenic, cadmium, lead, mercury, chromium, nickel, zinc and copper. The metals generated from the industries electroplating (nickel, zinc, and copper), tanneries (chromium), textiles and chemical industries, fertilizer and pesticides (arsenic) while organic pollutants are highly generated from distilleries, sugar, pulp and paper and tannery industries, lead acid batteries (lead), thermal power industries (mercury).

Among the toxic heavy metals, mercury, lead and cadmium are together termed as "the big three" which feature in the limelight due to their major impact on the environment. Arsenic, chromium, copper and zinc are also toxic; lead and cadmium are potent neurotoxin metals. On the whole, these toxic heavy metals are highly toxic to natural environment thereby affecting all living beings exposed to these toxicants. The following are the heavy metals mostly found in industrial effluents which when finds its pathway to our lifecycle affects our health.

4.0 ADSORPTION AND ADSORBENTS

Adsorption is one of the remedial techniques to remove the toxic heavy metals from the water medium. The phenomenon of concentration of a substance from water medium to the surface of a solid termed is termed as Adsorption. Adsorption can also be defined as "The change in concentration at the interfacial layer between two phases of a system due to surfaces forces". Adsorption procedure has attained a new dimension by the entry of innovative adsorbents. The adsorbents hold efficiency due to its high selectivity, good adsorption capacity. Some supports can be very useful for effectively decontaminating flowing water stream and effluents. Adsorbent is the solid support onto which the substance from the liquid medium would get adsorbed. Other remedial methods generally encounter the drawback of generating toxic sludge that requires further treatment before being released into the environment. Whereas, the remedial techniques based on adsorption efficiently control the mobility and bioavailability of adsorbed metal ions as compared to the conventional remedial methods.

5.0 RESULTS AND DISCUSSIONS

The study tries to contribute in the search for less expensive adsorbents and their utilization possibilities for elimination of heavy metals from wastewater and also assists industries to have best available practicable solution for the Indian scenario with respect to the agricultural and industrial sector. Many adsorbents have been reported to remove the heavy metal from the waste water. The major advantages of adsorption over conventional treatment methods include low cost, high efficiency, minimization of chemical or biological sludge, and regeneration of biosorbents and possibility of metal recovery.

5.1 ADSORBTION TO REMOVE ARSENIC

Sources	% Removed (As)	Time period
Plant Momordica charantia	88%	Immediately
Bean pods	99%	Immediately
maghemite nanoparticles	100%	Immediately
carbon black with an acid mixture	93%	Immediately
Groundnut husk	97%	Immediately
acid modified carbon black	93%	Immediately
surfactant-modified natural zeolites	99%	30 minutes
Iron coated zeolites	100%	30 minutes

Table 5.1 - Arsenic adsorbents and removal efficiency in %

The above table displays the removal efficiency of both natural and chemical adsorbents towards arsenic. Bean Pod and Maghemite nanoparticle are having capacity to remove arsenic from water medium immediately and quantitatively. Groundnut husk removes arsenic immediately with 97%efficiency. Whereas surfactant- modified natural zeolites and iron-coated zeolties display an efficiency of removing arsenic quantitatively to 100% within 30 minutes contact time.

5.2 ADSORBENTS TO REMOVE CHROMIUM

Sources	% Removed (CR)	Time period
cone biomass of pinus sylvestris	70%	Immediately
wheat bran	100%.	Immediately
Alligator weed	99.7%	Immediately
natural diatomite	97%.&82%	80minu & 22m
Helianthus annuus (sunflower)	81.7%	Immediately
activated carbon	100%.	Immediately
maize bran	98.7%	Immediately
Groundnut husk	97%	(5 hours)
Coconut tree saw dust	100%	Immediately
eucalyptus bark (EB)	100%	Immediately
Bagasse carbon	99.7%	Immediately
Rice husk carbon	90%	Immediately
Raw sugarcane bagasse	90%	Immediately
Raw bagassee	93%	immediately
Phosphate treated tree dust	100%	immediately
Palm pressed fibre	>80%	Immediately
Coconut husk	>80%	Immediately
Soya bean hulls	98.1	immediately
Cottonseed hulls	97.6	immediately
three Brazilian peats	>95.0%)	immediately
acid-treated Oedogonium hatei	75%	Immediately

The table displays that most of the adsorbents available for the removal of chromium are agricultural by- products such as rice husk carbon raw sugarcane bagasse coconut tree saw dust cottonseed husk etc. Wheat bran, maize bran, coconut tree sawdust, eucalyptus bark were reported to have quantitative adsorption capacity immediately towards the removal of chromium. Activated carbon and carbon generated from coconut jute, also displayed quantitative and rapid adsorption capacity towards the removal of chromium from waste water medium. The other agricultural by-products like raw sugarcane bagasse, Palm pressed fibre, coconut husk, soybean hulls, cottonseed hulls, Brazilian peats also displayed efficient capacity towards the removal of chromium from water medium.

5.3 ADSORBENTS TO REMOVE LEAD

Table: 5.3 Lead Adsorbents and Removal Efficiency in %

Sources	% Removed (Pb)	Time period
Tea waste(0.5- 1.5 g)	98%	Immediately
Waste mud (10 g L^{-1})	98.5%	Immediately
Orange peel	99%	20 minutes
wheat bran	99%	Immediately
Dyestuff- treated rice hulls (yellow)	100%	Immediately
Rice husk ash	100%	Immediately
Tartaric acid modified rice husk	>95%	Immediately
Sago waste	>95%	Immediately
pecan nutshell (PNS, Carya illinoensis)	95%	Time period
Chitosan / Titanium oxide hybrid film	90.6%.	immediately
hydrothermal liquefaction of pinewood and rice husk	99%	immediately
modified carbon black	~ 93%	immediately
grafted orange peel	99%	10 minutes
Pinus sylvestris sawdust	32% to 99%	immediately

The adsorbents like orange peel, wheat bran, rice husk ash, rice hull (treated with yellow dye), hydrothermal liquefied pinewood and rice husk are reported to have quantitative and rapid adsorption capacity towards the removal of lead from aqueous medium. The final study now lies in selecting the cost effective and efficient adsorbents for all the three toxic metal (considered for present study). The selected adsorbents would be recommended for the polluting Industries, who discharge toxic metal pollutants into water medium in the form of industrial effluent.

The adsorbents namely groundnut husk and bean pots proves out to be both natural, easily available and cheap adsorbent which could be used for the quantitative removal of arsenic from waste water and industrial effluents rapidly before discharging into agricultural field of any other water source. Arsenic is mostly discharged from semi conducts, fertilizer, insecticide, pesticide manufacturing industries. Even the cement and type manufacturing industries discharge arsenic as effluent. All the above mentioned industries are mostly based in the southern zone of India. Thus it could be suggested too these firm that the groundnut and beans cultivated in these regions itself could act as a solution for the arsenic discharged by them. Both groundnut and bean are aggressively cultivated in the southern India which forms the pathway of themselves being used as efficient, cheap easily available adsorbent for arsenic removal from industrial effluent. In the case of chromium removal wheat bran, coconut tree saw dust, eucalyptus bark, bagsse carbon could be used as best adsorbents. Chromium is mainly released as an efficient by industries electroplating industry, leather industry, and paint manufacturing firms. These industries widespread located everywhere around India. And for each zone of the country the best possible adsorbent have also been reported. Wheat bran and bagasse carbon could be the efficient adsorbents and rapidly for the removal of chromium quantitatively and rapidly from the industrial effluents generated by industries situated in northern and eastern part f India. Eucalyptus bark and coconut tree saw dust are available products of southern and western zones of India. Thus these both by- products could be acting as adsorbent for the quantitative removal of chromium from industrial effluents.

Lead is part of effluent in industries mostly where batteries and tyres are manufactured. These industries are situated in the western, northern, southern parts of the country, India. The adsorbents are also readily available for this toxic pollutant in each of these zones. Western India is famous for orange fruit cultivation. The orange peel itself is reported to be having quantitative capacity for the removal of lead. Wheat bran is available in northern India, which could act as adsorbent of Lead there in this zone. Rice husk ash could be available easily in southern India. Thus the best possible adsorbent for lead to be removed quantitatively and rapidly from industrial effluents is available in those regions itself where these pollutants arise.

6.0 CONCLUSION

Pollution is a threat full monster which is affecting our environment dead fully. As an economist, the best act would be to select the relief measures which are cheap, best and natural way of removing the pollutant before it enters of life cycle. Even if it cannot be prevented from being released, it can be avoided before it enters the natural medium. Industrial effluents from all different scales of industries are causing pollution. The most toxic pollutants are considered for the present study- Arsenic, Chromium and Lead. The relief measures which could be utilized by the industries (polluter) themselves, before determined. And more specifically for each zone of the country, the cost- effective adsorbents are suggested after having reviewed quantitative and rapid removal capacity of toxic pollutant. Groundnut husk and bean pots are suggested adsorbent for arsenic removal when it is released from industries located in the southern zone, Wheat bran, bagsse carbon and coconut tree saw dust, eucalyptus bark are being suggested as adsorbents for the removal of chromium from effluents released by industries, western zones of the country, respectively. Orange peel and wheat bran are recommended as adsorbents for the removal of lead from industries located in western and northern zone of India, respectively. Rice husk is recommended for lead removal in southern India. Thus these kinds of recommendations provided by we as economist to the industrial would, atleast for the Indian scenario could help them to avoid themselves from polluting the Mother nature. Especially for medium and small scale industries, who could not afford to set up effluent treatment plants as a part of their industry. As a first step, the suggested in their study. This could be narrowed down to each specific state, for eg: in Tamil Nadu, for dyeing industry in Tiruppur, the best adsorbents for them could be recommended. Or on the other hand, a broader picture could also be considered of which adsorbents is best suited for which country in the world, depending on the ready availability and efficiency of its removal capacity.

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