© 2019 IJSRSET | Volume 6 | Issue 3 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section : Engineering and Technology
DOI : 10.32628/IJSRSET1848180

Natural Adsorbents: The Potent Effective Solution to The Effluent Treatment of Sugar Industries

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ABSTRACT

Water is considered the most important element existing in all the living organisms and the most precious boon by nature for them to survive. Pure and fresh water is the basic need for the human consumption i.e .for drinking purpose or food cooking too. Now-a-days, it is a frightful fact; roughly a billion of people around the globe are deprived of pure, fresh and safe water to drink or for the use in kitchen. It goes without saying that water is considered the most important element in human life and its functions are very essential not only for human beings but also to all the living beings to survive. So, today, basic need for human consumption is the fresh and safe drinking water. But due to rapid expansion of industrialization and anthropogenic activities have contributed a lot in the economic progress and prosperity, but eventually disturbed the entire eco-system adversely, especially human beings. The presence of toxic heavy metals in aqueous system is the result of the untreated or not properly treated effluents discharging from different kinds of industries into the water bodies, generates the hazardous environmental problems or critical issues. Today, environmental pollution is supposed to be a burning issue for human beings and animals too. Toxic heavy metals are considered as the potent pollutants having the direct catastrophic effect on men and animals. One of the major strong impacts is that the water bodies have been become contaminated due to sugar industries' effluents containing piles of toxic heavy metals like lead, copper, cadmium, iron, chromium and nickel etc. So far, a number of effectual methods have been reviewed time to time for clearing the heavy metals such as chemical precipitation, ion exchange, reverse osmosis, adsorption, electro dialysis, coagulation, flocculation, lime softening and oxidation etc.

The most conventional treatment methods or strategies suffer of several disadvantages such as high reagent requirement, unpredictable metal ion removal and generation of toxic sludge etc. Instead of using conventional treatment methods or strategies, now-a-days, adsorption is assumed as one of the alternative treatment methods. In the adsorption method of treatment, the curious researcher often lays emphasis upon low cost natural adsorbents of natural origin for the treatment of effluents discharging from sugar industries. The usability of agro- based natural adsorbents has proven as a potent weapon in the recent decades as one of the most potent alternatives for effluent purification as compared to conventional or traditional heavy metals strategies. Tripathi and Rajan (2015) found that concentration of adsorbate, extent of surface modification and adsorbent characteristics are the factors responsible for metal adsorption capacity.

The present endeavor emphases upon the usability of agro-based low cost, natural adsorbents for removing the heavy metals from the effluents discharging from sugar industries along with methodology applied, because these are thought to be as the emerging innovative, low maintenance and energy efficient technology and the best resource for waste water purification, especially in the case of sugar industries' effluents.

Keywords : Conventional Methods, Adsorption, Low Cost Natural Adsorbents, Heavy Metals

I. INTRODUCTION

India is considered as an agrarian country and has been facing many environmental challenges due to urbanization, population explosion and industrialization. The accelerating pace of industrialization has a great health risk to plants, animals and human; and it is explicitly reflected in varying degree of water, soil and air pollution. Sugar industry is one of the most important agro based industries in India and plays key role for the development socio-economic sectors of a country through uplifting the livelihood and creation of new employments. The main product of sugar industries is white sugar; whereas by – products are alcohol, ethanol, and liquid CO2 and household textiles even though the effluents may be used as fertilizer after dilution.

Sugar filtering requires a huge amount of water during the number of steps and releases almost equal quantity of effluents containing toxic materials. Direct immediate discharge of effluents from sugar mills may have tremendous impact on surface and ground water along with physico- chemical and biological properties of soil. The outpouring/discharge of effluents is mostly organic having tiny quantum of inorganic materials. The effluents discharged from sugar industry carry loads of oxygen demanding waste and suspending matters which may result in depletion of dissolved oxygen and chocking of fish –gills, result in extinction of sea creature life. Roughly estimated, the discharges of such harmful effluents from sugar mills are around 500 cubic meters per day. The sugar mills' waste water is depicted by its brown color, low pH , high temperature, turbidity, electrical conductivity, chloride, high BOD, high COD, total alkalinity etc. So, this unprocessed waste water creates the problem to the environment and this leads to a serious public health problems and damage to environment. At large, surface water quality is deteriorated because of mixing of chemicals of the effluents into the ground water.

The regular releasing of untreated effluents from sugar industries in water bodies gives rise to the accumulation of toxic heavy metals in water bodies. Heavy metals are not bio-degradable and tend to accrue in living organism and causing cancerous diseases and different kinds of disorder in human and animals since effluents from large number of industries like sugar industries carry toxic metals like lead, Hg, Cd and As etc.

Effluents of Sugar Industries

Ozoh and Oladimeji (1984) claimed that sugar factory effluent produces obnoxious odour and unpleasant color when released into the environment without proper treatment. Farmers have been using these effluents for irrigation, found that the growth, yield and soil, health were reduced. Murty and Kumar (2004) revealed that the sugar industry is one of the most water polluting industries with the recently studied pollution concentration for some factories in India with as high as 1154 mg/l of BOD, 5915 mg/l of COD and 5759 ml/l for SS. Kaur and Sharma(2017) reported that maximum adsorption efficiency for the Zinc metal is obtained by using cassava waste(55.9%), cadmium by using smectite clay particle(97%), lead by using dried water Hyacinth stems and leaves (90%), copper and Nickel by using sugar baggase(94.2% & 87%) respectively. Amuda and Ibrahim (2006) found that coconut shell – based activated carbon was found to effectively adsorb organic matter. Sanjay, Swapnali, Ejaj,Sharad and Ajinkya (2017) pinpointed that rice

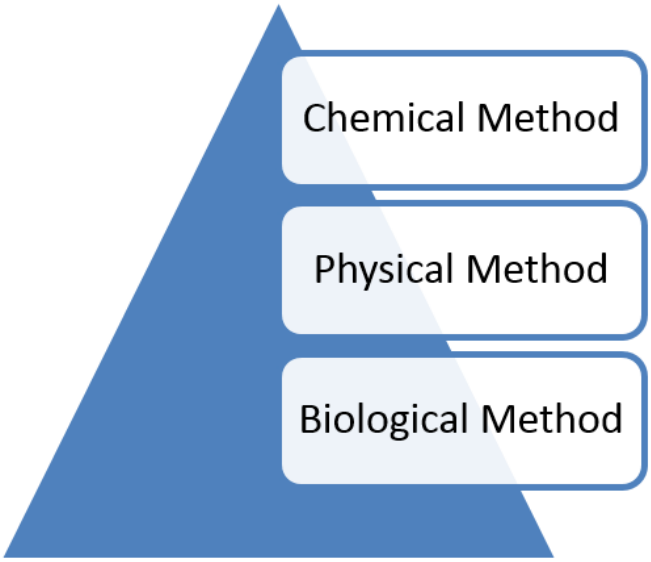
husk, neem bark, black gram, waste tea-coffee, walnut shell, coconut husk, bagas etc like most different natural absorbents can be utilized in the treatment method of heavy metals and therefore the rice husk, neem bark, black gram, waste tea – coffee , walnut shell coconut husk bagasse as an agricultural wastes are low cost material and so it might be convenient to use it in industrial waste water treatment plants.

The industries incur a significant cost to reduce these very influent concentrations of pollutants to the minimum national standards (MINAS) of 35 mg/l of BOD, 250mg/l of COD and 100 mg/l for SS in India. So, different pollution monitoring agencies like state and national pollution control boards have made compulsory for each industry to set up waste water treatment plant. Most of the waste treatment plants have primary state by addition of acid/ alkali for neutralization is causing side effects of increasing the amount of total dissolved and suspended solids. This effect hinders the effectiveness of subsequent treatment of lowering of COD, BOD, TDS, TSS amounts of oil and grease.

Ways of Sugar Industries' Waste-water Treatment

There are multiple types of treatment processes for waste water having contamination with heavy metals. Normally, effluents discharged from sugar industries can be treated by three conventional methods viz chemicals, physical and biological methods, which can be further subdivided as follows

Treatment methods for Sugar Industries Effluents



Chemical Methods

1. Oxidation
2. Electrolysis
3. Ozonation

Physical Methods

1. Reverse Osmosis (Membrane treatment)
2. Filtration
3. Coagulation/ flocculation
4. Adsorption

Biological Methods

1. Micro organisms
2. Enzymes

Some advantageous techniques and methods have been developed in past, but the main problem with them is that the socio-economic conditions do not allow the application of those techniques and methods easily in the developing countries. So, there is a dire need to invent the low cost techniques for the removal of heavy metals and other impurities from waste water. So that, the safe water may be available to consumer's end. Numerous technologies have been developed over the years to purify industrial effluents. The prominent important

technologies include coagulation/ flocculation process, membrane filtration, oxidation process etc. So, nowadays, adsorption has become one of the alternative treatments for the waste water.

Why Adsorption Method Significant over Others

Amongst numerous water treatment technologies, adsorption is considered as the most versatile process. Major disadvantages in other methods are such as the requirement of high reagent and high energy consumption, unaffordable, complicated to handle, requiring the skilled personnel and above all not eco-friendly.

Most of these existing methods suffer from the obstacles such as high capital and operating expenses, problem concerning the throw away of the residual metal sludge. Therefore, out of all these available methods, adsorption appears to be simple and less troublesome.

Tremendous Advantages of Adsorption Method

The key benefits of adsorption method for removing the heavy metals from the waste water are such as less initial as well as operating expenses, unproblematic design, less requirement of control system. Generally the heavy metals are found in the waste water at low concentration; therefore adsorption is considered fit/suitable in even when the metal ions exist at concentration at low as 1 mg/l. It proves the adsorption method an economical and favorable technology for heavy metal removal from waste water.

Affordable natural Adsorbents Vs Commercial Adsorbents

Adsorption by commercial adsorbents has some these advantages over low cost natural adsorbents – slow reaction, high regeneration cost, expensive, not eco-friendly, often more secondary effluent producers; but adsorption by natural adsorbents provide the following advantages-easily available, inexpensive, high eco-friendly, highly effective, economical, and easy to operate and lesser secondary effluents producer.

The concept of Adsorption

Adsorption is surface phenomenon with common procedure for organic and inorganic pollutants' removal. For removing the organic contaminants, adsorption is considered as the best method. Basically, adsorption is a mass transferring process by which a substance is transferred from the liquid phase to the surface of a solid and become bound by physical and/ or chemical interaction. There are three key steps followed in pollutant sorption onto solid sorbent:

1. The transport of the pollutant from the bulk solution to the sorbent surface
2. Adsorption on the particle surface, and
3. Transport within sorbent particle

Mechanism of the Adsorption

It is a heat releasing process which means that energy is liberated during this process. The amount of heat that gets evolved when one mole of the adsorbate is adsorbed on adsorbent is described as enthalpy (heat capacity) of adsorption. At constant temperature and pressure, adsorptions occur spontaneously.

The important reason for taking the adsorption is that the molecules on the surface and the molecule in the bulk do not exist in the same condition. There is attracting force from every side on the particles in the bulk or gross and remain balance but the molecules on the surface do not have attraction from all the sides and so they are not balanced, these are residual forces.

These residual forces are accountable for drawing the attraction of the adsorbent on their surface. At the given temperature and pressure, the adsorption depends on the surface area. More surface area refers to more attraction, more adsorption. If surface area is less, there will be less attraction and less adsorption.

The next causing circumstance/ factor in the adsorption.

But if area of the surface is less, then attraction will be less and so adsorption will be less. The second factor in the adsorption mechanism is the heat of adsorption. It is an exothermic / heat releasing phenomenon or the value of ΔH is negative. The destruction of the molecule decreases due to adsorption. Hence, ΔH becomes negative. So, in nutshell, it can be said that the adsorption is associated with decrease in both ΔH and ΔS. Adsorption is spontaneous, so at constant T and P, Gibb's free energy ΔG decreases since G = ΔH-TΔS. The mobility of ions and rate of interactions between oppositively charged ions and adsorbent surfaces are more observable in dilute solution. The adsorption surfaces of different materials contain various ionic structure or properties. It may be attributed to their protein, carbohydrate and phenolic compounds which have metal binding functional groups such as carbonyl, hydroxyl, sulphate, phosphate and amino group.

Properties of Adsorbents

An adsorbent contains high selectivity to facilitate quick separations, favorable transport, kinetic properties, thermal and chemical stability, and mechanic strength, resistance to fouling, regeneration capacity and low solubility in the liquid in the contact. Adsorption capacity of adsorbents basically depends on the properties materials as specific surface area, pore size and its distribution. A decrease in the size of particle of adsorbents augments the adsorption, because as the decline in the size of particle increase availability of the number of the active size, the result then better is the adsorption.

Low Cost Natural Adsorbents

Now-a-days, adsorption is considered one of the alternative treatments. In recent years; the search for low cost adsorbents having metal-binding capacities has intensified. The natural adsorbents may be of minerals, organic or biological origin and / or zeolites. The term low cost natural adsorbents drawn from:

1. Agricultural sources and by-products (fruits, vegetables, foods)
2. Agricultural residues and wastes
3. Low cost sources from within more complex adsorbents will be produced (ie activated carbons after pyrolysis of agricultural sources)

The natural adsorbents are often thought to be inferior (regarding their adsorption capacity) as compared to the super adsorbents (complex materials as modified chitosans, activated carbon, structurally complex inorganic composite materials etc.) but their cost potential makes the competitive.

Selecting the Appropriate Adsorbents

Technical applicability and cost- effectiveness are the key factors that play major role in selecting the most suitable adsorbent to treat inorganic effluent successfully.

Significance of Adsorption Method

Now-a-days, adsorption has become one of the potent alternative treatments. In recent years, the researches for low cost adsorption that have metal binding capacities, has raised. The main motto of the present endeavor is to use the natural adsorbents (materials) for the treatment of the effluent discharging from the sugar industries due to the economically feasible and eco-friendly technology; it can be used especially in underdeveloped and developing countries to control over the contaminated effluents discharge; especially from sugar industries effectively. Now-a-days, the removal of toxic heavy metals by agro-based waste material is highly effective, inexpensive, easily available and very easy to operate along with lesser secondary effluent produces and above all, its eco-friendliness. The current researches reveal that more than 80-90% adsorption in waste water treatment takes place easily by natural adsorbents. It shows that for the

removal of organic and inorganic pollutants, adsorption may be considered the best method. The appraisal of appropriate natural adsorbent's performance will be carried out using the following way:

(Effluent before treatment)

Vs

(Effluent after treatment, using natural adsorbent)

Methodology - Two modes of removal are as follows:

A. In one of experiments, effluents from sugar industry are run through column packed with natural adsorption.
B. In the other set, the effluents from sugar industry are simply agitated with known weights of the natural adsorbents.

Heavy metal concentrations of the sugar industry effluents are determined before and after contact with natural adsorbents using AAS (Atomic Absorption Spectroscopy).

Parameters such as column height, substrate weight, particle size of the substrate and the pH of the substrate in solution are varied to obtain optimum condition for heavy metal removal virtually all the materials (natural adsorbents) are found to be good scavengers of heavy metals comparable to the conventional, expensive, commercial materials such as ion- exchange resins commonly used for waste water treatment.

The adsorption capacity of the natural adsorbents varies from one heavy metal. Which one out of the two methods as mentioned above, along with suitable adsorbents is set for the treatment of sugar industry effluent after minutely analyzing the available conditions, which we find after doing physico-chemical analysis of the effluents are taken in the sample from sugar industry. Our present endeavor suggests that, heavy metal concentration of the sugar industry effluents should be determined before and after contact with the natural adsorbent by using A.A.S.

II. SCOPE IN FUTURE

Low cost adsorbents can be used for water treatment and waste management effectively, now-a-days; there is a dire need to develop more efficient, selective, inexpensive and eco-friendly natural adsorbents. Many research works should still be carried out in the area of desorption.

III.CONCLUSION

A review of various processes and adsorbents for heavy metal removal indicates that adsorption process has great potential for the elimination of heavy metals from sugar industries waste water using low cost natural adsorbents. More studies should still be carried out for low cost adsorption process to promote on large scale by using of non-conventional adsorbents

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Cite this article as :

Mrs. Sujata Malik, "Natural Adsorbents: The Potent Effective Solution to The Effluent Treatment of Sugar Industries ", International Journal of Scientific Research in Science, Engineering and Technology (IJSRSET), Online ISSN : 2394-4099, Print ISSN : 2395-1990, Volume 6 Issue 3, pp. 370-376, May-June 2019.

Journal URL : http://ijsrset.com/IJSRSET1848180