Proceedings World Geothermal Congress 2020+1
Reykjavik, Iceland, April - October 2021

Geothermal Water Purification by Green Adsorbent

Het Tilala[1], Hemil Savaliya[2], Deep Kotadia[3], Manan Shah[4]

[1,2,3,4] Department of Chemical Engineering, School of Technology, Pandit Deendayal Petroleum University, Gandhinagar-382007, Gujarat, India

Email id: het.tch19@sot.pdpu.ac.in hemil.sch19@sot.pdpu.ac.in deep.kch19@sot.pdpu.ac.in Manan.shah.@spt.pdpu.ac.in

Keywords: Geothermal Energy, Water; Adsorbent; Green energy

ABSTRACT

This paper provides a critical overview of purification of geothermal water by green absorbents. Geothermal water is highly useful and filled with abundant sources, and it is highly useful for the humans. Geothermal water is a chief natural resource in the Earth. It supports all the lives on the earth and plays a vital role in the development of humans. Geothermal water is very useful in household purposes, and it is also used for irrigation purposes. The recently growing industries occupation to the desires and luxuries of individuals consume volumes of water for his or her use. Geothermal water supplies are at risk of chemical pollution from fracking, agricultural chemicals, leaking or unfit landfills, and septic tanks. Such contamination can render geothermal water unfit for use and difficult to clean up. For those reasons it needs to be purified for the better use of it. Activated carbon, bio char, and fruit peels seem to be low cost adsorbents, and the natural adsorbents for the removal of heavy metals from the geothermal water. Activated carbon is the most generally used adsorbent because of its low value, exceptionally high porousness, tunable pore size, and high adsorbent capacities. Biochar as a stable carbon-rich material shows unbelievable potential to handle contaminants present in water. Fruit peels were chosen and used as green adsorbents for water purification. Thus, purifying geothermal water with this natural adsorbent, we can make the best use of geothermal water in house hold purposes and many industrial aspects.

1. INTRODUCTION

Water is one among the universal substances. We human beings need clean water to survive, but now we are heading towards a water crisis (Patel et al., 2020). These industrial activities indirectly overload water bodies with thousands of water pollutants, and subsequently polluting the environment. Basic domestic water quantity needs are divided into categories including water for drinking, cooking, hygiene, and other domestic purposes. The ground water in shallow aquifers is generally suitable to use for different purposes and is mainly containing calcium carbonates and bicarbonates. The main ground water quality problems in India are salinity, arsenic, nitrates, fluorides, etc. Drinking water is being the biggest issue nowadays in India, because in rural areas they are not getting enough facilities, like water filters and mineral water bottles. To overcome this problem many efforts have been done, due to which cleaning water may become an affordable solution through more natural ways, such as activated carbon, fly ash, fruit peels, bio char etc (Sircar et al., 2017; Pandya et al., 2019).

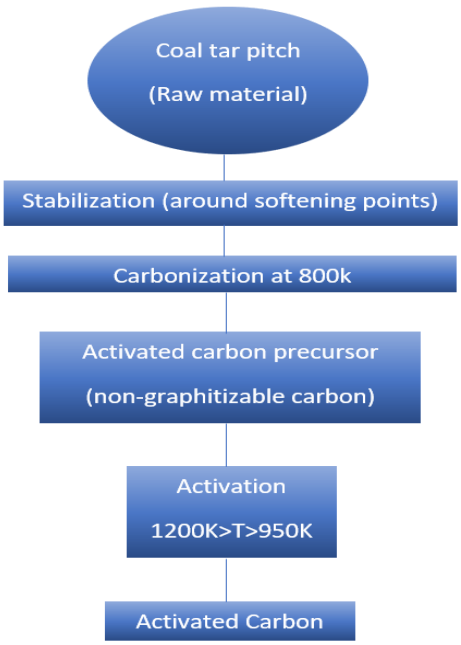

Figure 1 Process for manufacturing of Adsorbent

Agricultural residues, fruits peels are the discarded waste materials and find no application anywhere. They can be used as low-cost adsorbent after little processing. Various bio adsorbent like orange peels, watermelon peels, pomelo peels, and other peels are tested for the extraction of heavy metal ions and dyes from water. Although the use of agricultural waste peels-based adsorbents for removing various pollutants from water offers many attractive features, but still there are several gaps which need more attention.

Agricultural waste peels adsorbents should be made more efficient, reusable, and applicable to multicomponent real industrial effluents (Shah et al., 2020).

Biochar as a stable carbon-rich material exhibits incredible potential to handle groundwater contaminants. Biochar as an eco-friendly and low-cost material usually produced from organic wastes, such as agricultural wastes, municipal wastes and forestry residues, has attracted increasing attention evidenced by its increasing use in different environmental applications. Organic wastes could be converted into char by different techniques such as pyrolysis, hydrothermal carbonization (HTC), gasification, and torrefaction. The traditional carbonization methodology for producing biochar is pyrolysis, while chars from gasification, torrefaction, and HTC generally do not meet the definition of biochar specified in the guidelines for the European Biochar Certificate (EBC).

Figure 2 Classifications of Agriculture Waste Peels

2. PROCESS TO PURIFY GROUNDWATER BY LOW-COST METHODS

2.1 Biochar

Various mechanisms might play a role in controlling heavy metals removal from geothermal water using biochar, including precipitation, complexation, ion exchange, electrostatic interaction (chemisorption), and physical sorption. Biochar having high surface area and pore volumes have a greater affinity for metals, because metallic ions can be physically absorbed onto the char surface and retained within the pores. Many biochar surfaces have negatively charged and can sorb metals positively charged through electrostatic attractions, ligands. Specificity and various functional groups on biochar can also interact with various heavy metals by forming complexities, or precipitates, of their solid mineral phases. Compared with activated carbon, biochar appears to be a replacement as it is low-cost and effective adsorbent. The activated carbon production needs higher temperature and additional activation process. Therefore, the biochar production is cheaper with lower energy requirements. Physical or surface sorption describes the heavy metals removal by diffusional movement of metal ions into sorbent pores, without formation of chemical bonds. Heavy metals sorption, through exchange of ionizable cations/ protons on biochar surfaces with dissolved metal species, is an alternative mechanism. Electrostatic interaction between surface charged biochar and metal ions is another mechanism for the heavy metal immobilization from geothermal water. Mechanism of biochar mainly rely upon biochar-metal sorption process which depends on pH solution and point of zero charge of biochar. At High temperatures (>400°C) of carbonization promote the formation of grapheme structures in the chars to favor electrostatic attractions sorption mechanisms. At the time of sorption process, precipitation is the formation of solid(s), either in solution or on a surface. Precipitation is an essential mechanism responsible for the immobilization of heavy metals using biochar sorbents from the groundwater. Due to the optimization of adsorption process, pH of the solution is the most vital parameters. It effects charge surface area, degree of ionization and speciation of adsorbent. Biochar carried various surface functional groups (mainly oxygen containing groups). Change in these functional group acts with the increase of the pH solution. At low pH, functional groups on biochar present in the form of positively charged, report that the pyrolytic temperature significantly influence the structural, morphological, elemental and properties of biochar. As per the literature studies of geothermal water treatment, the biochar process can remove the metals like lead, Arsenic, Chlorine, Nickel and many other pollutants from geothermal water.

2.2 Fruit Peels

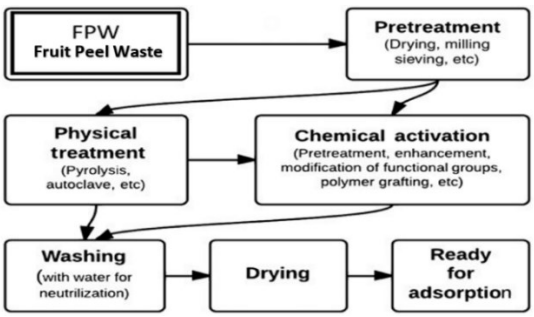

Figure 3 Schematic Diagram for Processing Different Types of Native FPW

Figure 4 Avocado, Dragon and Hamimelon Peel

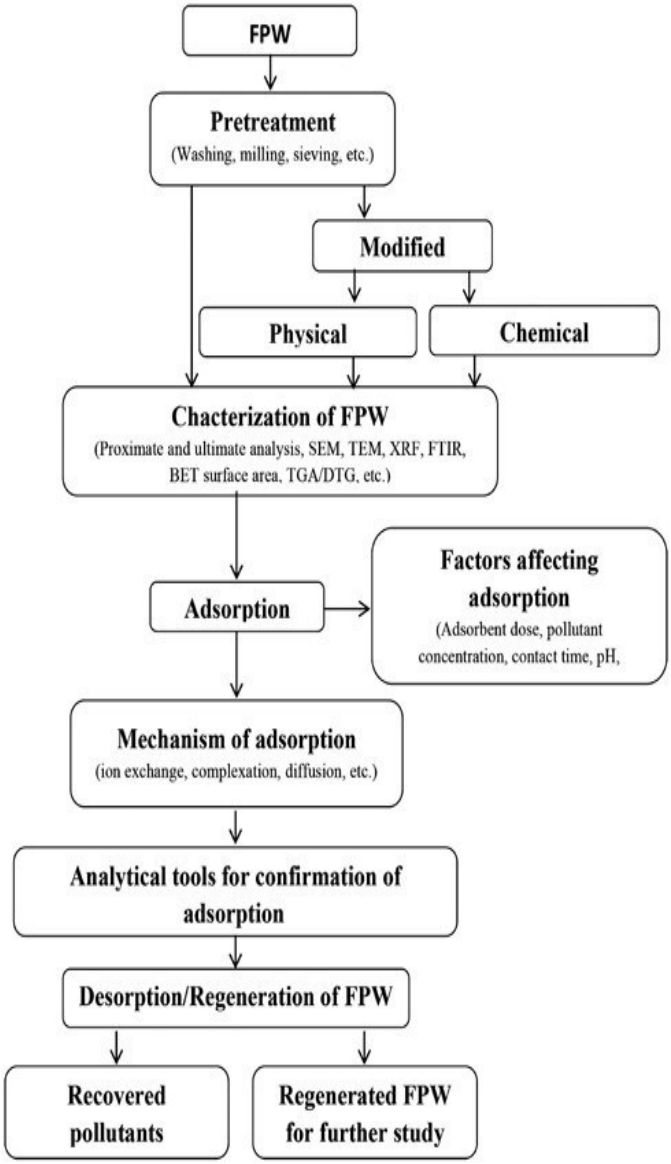

Figure 5 Overall Adsorption Process using FPW

Step 1 – Preparation of fruit waste peel adsorbent from local supermarket. Washed with water, peeled the outer layer, and cut into small pieces. Raw peels were saponified with NaOH, followed by thorough washing with deionized water to remove excess base. Washed peels were sonicated in 2-proponol to extract soluble organics and then filtered, washed with water, and dried.

Step 2 – In characterization method, surface of fruit peels were scanned using field emission scanning electron microscope (FESEM, JEOL JSM-6701F). For the determination of chemical composition of fruit peels, Energy dispersive X-ray spectroscope (EDS)is used. The concentrations of metal pollutants in experimental and control samples were analyzed using inductively coupled plasma optical emission spectroscopy (ICP-OES, Dual-view Optima 5300 DV ICP-OES system). Carbon, hydrogen, nitrogen and sulphur (CHNS) analyses were done using an Elementary Varia Micro Cube instrument.

Step 3 – In Batch Adsorption studies, there are 2 effects taken, one is Effect of Initial Adsorbate Concentration and Time, and second is Effect of Solution pH.

By using fruit peels, we can extract the heavy metal like chromium, iron, selenium, vanadium, copper, cobalt, nickel, cadmium, mercury, arsenic, lead, and zinc from geothermal water, the major toxic hazardous materials to humans and other forms of life.

2.3 Activated Carbon

Adsorption is a process where soluble substance are removed by using solids (Activated carbon). Activated carbon is produced to achieve a very big internal surface (between 500 - 1500 m2/g). This big internal surface makes active carbon ideal for adsorption. Active carbon comes in two variations: Powder Activated Carbon (PAC) and Granular Activated Carbon (GAC). The GAC version is mostly used in water treatment, it can adsorb the following soluble substances:

- Non soluble substance in water
- Chlorine
- Phenol
- Yeasts
- Various fermentation products

Activated carbon is used for the process such as

- De-chlorination process
- Geothermal water purification

Water is pumped through a column consisting of activated carbon filters, which is a commonly used technology to purify the ground water. This method is effective in removing Hydrogen Sulphide, Radon, Chlorine, Volatile Organic Compounds, Pesticides, Benzene, Colours, and Odours from drinking water or groundwater. The adsorption efficiency depends on the nature of activated carbon used, the water composition, and operating parameters. There are many types of activated carbon filters that can be designed for residential and commercial purposes. Activated carbon filters are low-cost adsorbents which satisfies basic requirements of purifying the ground water, but it has only one drawback, that it needs constant replacements after a definite period of time.

Some experiments were carried out by creating synthetic fluoride water and then passed through sands, pebbles, and adsorbents (activated carbon) and then tested for significant water quality parameters such as Acidity, Alkalinity, Total dissolved solids, pH, Total hardness, Calcium hardness, Magnesium hardness, and Fluoride.

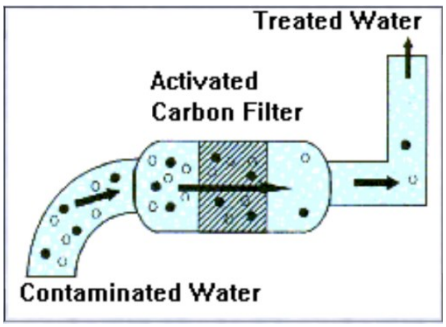

Figure 6 Water Treatment using Adsorbent

3. CHALLENGES AND FUTURE SCOPE

3.1 Bio char

Since the utilization of biochar for groundwater depollution depends on the biochar properties, such as functional groups and surface area, on the availability and the nature of feedstock and on the conditions of thermal conversion methodology adopted for the biochar production. Biochar modification is an important area that has to be exploited to enhance the biochar capacity for the removal of specific contaminants. The understanding of the relationship between thermal conversion conditions, biochar properties, and biochar behavior toward groundwater contaminants can encourage its use for very complex compounds that hinder, for example, biological processes adopted for groundwater treatment. Hence, biochar could be incorporated in the pre-treatment processes and adopted to remove toxic compounds for subsequent biological treatment. Along with the wide application of biochar

in the groundwater treatment field, scientists should pay attention to its potential negative effect on the environment. The stability of biochar is one among the foremost most important properties that has to be taken into consideration when biochar is used. Generally, the stability of biochar refers to its aromaticity and degree of aromatic condensation. When biochar is used for groundwater decontamination, the potential release of carbon from the biochar can increase the carbon content in the solution to be treated. Furthermore, a release of heavy metals could also occur, especially for biochar derived from sludge. The dissolution of organic matter from biochar into the geothermal water is because of the biochar instability. The stability of the biochar was also found to usually decrease after several cycles when the biochar is used as a support for catalyst, because of the variation in the carbon structure of the biochar. The stability of biochar depends on the nature of the starting feedstock, and on the experimental conditions used during its thermal conversion. Therefore, it is necessary to identify the correlation between these two parameters and the biochar stability. Another key factor is the regeneration and recovery of biochar after use. Generally, the adsorption process is consisting of the transformation of pollution from the liquid phase to the solid material/adsorbent. Hence, its necessary to convert the toxic pollutants that are bound with the biochar into a non-toxic state for their efficient management.

3.2 Fruits peels

FPW adsorption is in its development stages and requires further research needed to get insight on the process. Most of the reported studies are focused only on batch mode. Column studies should, however, be carried out, which would help in scaling up and designing for commercial applications. FPWs are natural biomaterials. Their properties and surface characteristics depend on various parameters like (1) location of the source, (2) geological condition of the location, (3) season, (4) ripening state of the fruit, and (5) quality and type of fruit. Pretreatment of the peels increases adsorption performance, but it is a costly preposition at industrial level. Some innovative and economic processes should be evolved for pre-treatment to meet the industrial standards.

3.3 Activated carbon

As activated carbon satisfies basic requirements to purify the ground water by removing chlorine, fluoride, radon and many more insoluble substances, so this can be used in near future, as population is continuously increasing and their water requirements are not matching. Nowadays, boring is the solution to match the requirement, but it is not as healthy and safe water as municipality water. Due to this reason we can develop the purifying system which can do basic purification and there we can use activated carbons as filters, and that will be low-cost purifying system. But as we say all good things come with some difficulties. The main problems that we will face is to operate this system requires skilled labour, so it will add labour costs, and filters need to be replaced at several time intervals, which will increase the cost.

4. CONCLUSION

Adsorption mechanisms analysis reveals that different kinds of interactions including chemical bonding, chemical interaction, precipitation, physical adsorption, ion-exchange, and electrostatic attraction are predominantly responsible for binding wastewater pollutants. And due to its high surface area, charged surface, and functional groups, influencing depth, control density, Biochar is of great potential to adsorb heavy metal and organic contaminants. Addition of Biochar should decrease the Leachability, bioavailability, toxicity, and mobility of organic and inorganic pollutants. Biosorption using FPW is a new process that has shown good promise for the removal of different organic and inorganic contaminants from aqueous effluents. In this article, FPW as an adsorbent for different organic and inorganic contaminants has been reviewed. Three bio peels, avocado, hamimelon, and dragon fruit peels were investigated as potential bio adsorbents for the extraction of dissolved pollutants in water. Dragon fruit peels showed the highest extraction efficiency, close to 100%, toward alcian blue (71.85 mg/g) and methylene blue (62.58 mg/g) at neutral pH values. Hamimelon peels showed an extraction efficiency of Pb^{2+} (7.89 mg/g) and Ni^{2+} (9.45 mg/g) cations. The main advantages of the use of these materials are their availability (because they can be obtained relatively easy), their low cost, and the fact that they do not require culture or synthesis for their production. Activated carbon is used in water filtering systems as it has excellent adsorption capacity. The pores of activated carbon trapped and locked water contaminants during the water filtering process. And from the experiment of purification of synthetic water containing fluoride, it is proved that activated carbon removes the total hardness compared to fly ash and other ingredients used to purify it.

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