Adsorbent from waste tires as activated carbon for removal of heavy metals from waste water - A review

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Abstract. Globally there is an increasing need for green solutions to environmental challenges. One of the many challenges that plagues our environment is the problem of heavy metals especially those from waste water. Heavy metals are very difficult to remove using simple chemical processes, and when not properly removed during distillation processes it can find its way to drinking water thereby causing serious health challenges like damage of important organs and even cancer. How ubiquitous this problem is and the fact that waste water is part of every thriving urban community calls for very innovative approach to solving this challenge of heavy metals in waste water. This study uses an innovative approach to solving this challenge, by using carbon found in waste tires as an adsorbent for removing heavy metals. Our approach is using a waste material very endemic in our communities to solve another waste material which is causing problem to health and environment. The ripple effect of our approach is that it helps reduce tires waste in our surrounding, while also removing heavy metals from waste water.

Key Words. Metal Air Battery, Sustainable Energy Storage Device, Aluminum-air, Zinc –air.

1. Introduction

Worldometer.info projects that globally there are over 1 billion amounts of cars; this statistics gives us insight into a bigger issue which most time goes ignored [1]. Each car is a potential waste manufacturing industry in itself. The amount of carbon (II) Oxide, these cars produce plus constantly churning out millions and billions of used and spoilt tires yearly, the global impact of these billions of cars can never be underestimated [2]. The used or dumped tires have two major problems, the first is with its constituent and the second is with the cost of proper dumping [3]. Vehicle tires are composed of: Natural rubber, synthetic polymers, steel, textile, fillers (Carbon Black, Amorphous Precipitated Silica), antioxidants, antiozonants, curing systems (Sulfur, Zinc Oxide) in proper percentages [4]. Some of these components like zinc, chromium, lead, copper, cadmium and sulphur from these tires breakdown and become major problems that are detrimental to our environment [5]. The second problem is with the cost of proper dumping of tire waste [6]. To properly dispose a tire is expensive and needs some storing facility which is not verily available to most vehicle owners, as a result they resort to burying most of these tires or
burning it, either way is not environmentally friendly, because burying these tires after further disintegration releases toxic elements into the environment like zinc, lead etc. and burning those tires further causes air pollution [6]. With this increase in pollution is the need for better and more economical means of utilizing tire waste [7]. This is what activated carbon (carbon black) helps us to achieve. Being a major constituent of tires it has a major property of adsorption, which can help in adsorption of heavy metals from waste water [8]. On an average each domestic household produces 200–300 Liters of wastewater per person every day, about 99% of this wastewater is water, and the other 1% contains contaminating wastes, which contains heavy metals and pollutants [9]. On an average 200 Liters of water wastes per person daily, the goal of science is always to reduce waste, since just 1% of these waste are pollutants, proper purifying techniques becomes essential [10]. These pollutants are easily absorbed by carbon black to form precipitates of the heavy metal, thereby causing easy decantation of the water while separating the pollutants; this is why using activated charcoal from tire waste which is readily available becomes an important approach [11].

2. Activated Charcoal
This is an odorless, tasteless non-hazardous amorphous carbon also called activated carbon or carbon black. It has a porous structure and a large surface area of up to 1,500 m²/g [12]. The structure of activated carbon look like a crude form of graphite, with some haphazard amorphous structure with different range of pore sizes, from visible voids and holes to those of larger molecular sizes [13]. The major physical property of activated charcoal is its adsorption property, this accounts for its usage as an adsorbent for pollutants, this property stems from the large surface area of amorphous carbon, making it to be able to attract and retain heavy metals [14]. The chemical structure of activated charcoal is shown in Figure 1.

![Figure 1: Chemical structure of activated charcoal [13]](image-url)
3. Production and Adsorption Capacity of Activated Charcoal

Activated carbon can be prepared using this process. Fire wood or any other compatible wood is dried at about 105-115°C for 24 hrs, then placed in an oven which is sealed and heated at a rate of about 5°C/min from room temperature gradually to 450°C. Simultaneously, N₂ is passed into the oven at a rate of 3 dm³/min for 1 and half hour. For the carbonization process, the char will be soaked in a concentrated NaOH solution. Then later on it is oven-dried and activated. The activated products is then cooled to room temperature and washed clean with distilled water. The resulting sample is then decanted into a container containing 0.1 mol/dm³ HCl (250 cm³) and stirred rigorously for 1 hour. Then finally it is washed with hot water until neutral pH is obtained within the range of 6-7. On an average about 20–25 g solvent per 100 g activated carbon can be adsorbed when effective adsorption takes place using activated charcoal. If the adsorbent is a poor adsorber, the temperature or the air humidity increase, then capacity will decreases. Impregnated activated carbon, are prepared differently. Adsorption can be done in a bed composed of activated carbon. An adsorption zone is then formed around bed, which when saturated moves the air inlet to the outlet. When the air gets to the saturation zone at 100% input concentration level it leaves the zone at the lowest possible vapor pressure in equilibrium relation with the activated carbon [14, 15].

4. Activated charcoal from waste tires as treatment for waste water

Several methods have been deployed by different chemist to effectively extract activated charcoal from waste tires; we will explore two among such popular methods. In his method carbonaceous adsorbents was prepared by reaction of HCl, HNO₃, and NaOH aqueous solutions in an atmosphere of N₂. Next, these adsorbents are characterized by their texture and tested as adsorbents of phenol, paminophenol, p-nitrophenol, of metals in aqueous solutions. The result is a carbonaceous pyrolous adsorbent that is used for the removal of heavy metals such as mercury and lead from liquid solutions in this case waste water. The tire obtained activated carbon was used for the removal of Cu (II) and Pb (II) ions from wastewater collected from domestic water waste. The prepared adsorbent was by scanning electron microscopy method. For optimization purposes, factors such as P.H value, time, concentration of solution and mass adsorbent were effectively studied [16].

Using whatever method the general production of adsorbent from waste tires follows the following steps

- Cleaning and washing of raw material
- Drying
- Pyrolysis
- Oxidation
- Re-washing
- Re-drying
- Oxidation
- Activation
- Final Washing and drying
- Sieving

5. Factors affecting the efficiency of activated charcoal when treating heavy metals in waste water

Few factors affect the production of activated charcoal, Mousavi et al., in the year of 2010 did a research on used ash of waste tire rubber as an adsorbent in the removal of heavy metal ion from liquid phase [17]. They conducted Batch adsorption studies on the effect of pH, temperature, and effect of contact time in the adsorption of heavy metals using activated charcoal, their conclusion showed that these factors contribute in many ways in the adsorption process. They discovered that removal of heavy metals by adsorbents in this case activated charcoal depends largely on the pH of its initial concentration. Batch equilibrium studies were carried out in using pH values to ascertain this. Manchon-Vizuete et al., 2005 did another research using waste tires to prepare carbonaceous products and these carbonaceous products were used as an adsorbent for the removal of mercury from liquid solution [18]. The adsorption of mercury was studied from its kinetic and equilibrium characteristics. In their research paper they
concluded that adsorption capacity of tire towards mercury increases when the adsorbent is consecutively heated and cured chemically. While using activated charcoal as an adsorbent to treat waste water it is necessary that we observe the optimal conditions as determined by these stated researches and more, to be able to treat waste water effectively and optimally remove all heavy metals in the waste water.

6. Conclusion
Removal of heavy metals from waste water is a very important process in the purification and recycling of waste water. In this paper we established the fact that waste tire contains activated charcoal, and with further analysis we realized that activated charcoal is a good adsorbent for removal of heavy metals from waste water. Being cheap and readily available makes it suitable for this purpose. We also did a research into the works of other chemist on this similar topic and we discovered that the PH of the initial concentration and the amount of heat applied can affect the adsorption efficiency of activated charcoal. Considering the challenge of waste water, this paper came to the conclusion that, activated from waste tires provides a better means of adsorbing heavy metals from waste water.

7. References
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