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A Case Study on Advanced Water Treatment by Adsorption Techniques

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ABSTRACT: WASTEWATER TREATMENT is a major issue and big problem in today's scenario, the wastewater is used water from any combination of society like domestic, industrial and commercial or any sewer inflow and so on... There are different methods to treat wastewater, but in the economic aspect the adsorption is economical than others. In the adsorption process there are different adsorbent but in this review paper we conclude several reviews by different scientists and professor on Activated Charcoal/Carbon. Activated carbon (AC) is used in different states of applications after its discovery as a strong and reliable adsorbent.

An overview on AC is presented together with revisiting the sources of AC generation; methods used to generate AC comprising of pyrolysis activation; physical activation; chemical activation and steam pyrolysis. AC is applied in water, wastewater and leachate treatments in many countries, especially to polish the colour, remove the odor and some heavy metals. It is cheap and available, and can be produced from agricultural waste materials, e.g. rice husk, palm oil shell and coconut shell. The AC's fine and porous structure and an extremely large particle surface area (>1000 m² /g) results in making it possessed powerful adsorptive properties.

Therefore, the adsorption process using AC is found to be a potentially viable method of removing pollutants from aqueous solutions.

KEYWORDS: AC (Activated carbon/charcoal), adsorption, wastewater treatment, adsorbent...

I. INTRODUCTION

The human population is growing tremendously accordingly the demand of water is increased and also the wastewater is increased. On the other side waste management becoming a major issue worldwide. The generation of wastewater in today's life is increased on the daily basis due to this the treatment of wastewater is a major issue that could be concerned. Here the process adsorption is used to treat the wastewater by the help of different adsorbent like, activated carbon, silica gel, Zeolite, activated alumina and most industrial **adsorbents** fall into one of three classes: Oxygen-containing compounds, are typically hydrophilic and polar, including materials such as silica gel and zeolites. Carbon-based compounds, are typically hydrophobic and non-polar, including materials such as activated carbon and graphite. Here we reviewed activated carbon which is cheap and easily available and mostly used adsorbent.

- The origin of activated carbon (AC) is associated with Ancient Egypt (1500 BC), whereby the Egyptians make use of its adsorbent characteristics for water purifications and medicinal purposes. During the last few years, adsorption of gases on charcoal has been reported by a Swedish chemist, Karl Wilhelm. Within recent decades, the AC was used in industries as a decolorizing agent.
- However, the potential use of AC was actually capitalized during the First World War, whereby AC was used in gas mask against toxic gases. Respiratory protective devices were developed as personal protective tools against the use of toxic gases during wars. Hence, granular activated carbon (GAC) has found application during the first World War and still been used nowadays [12, 15, 13, 11].
- During the beginning of 20th century, the first AC production plant was commissioned in Germany purposely for a sugar refining industry. Lately, some of the plants emerged to produce AC for wastewater treatment processes. Recently, the AC is abundantly utilized as an air purifier in atmospheric air contaminant cleaning, color removal of industrial and automobile exhaust, food and pharmaceutical products also used as refrigerator deodorizers and in advanced applications such as nuclear plants.
- In the late 1930's undoubtedly, AC gained huge momentum and popularity in industrial sectors, for both gaseous and aqueous phase applications.



- In fact, various new carbon production processes were developed to meet the continuous increasing industrial needs. Within the period of 1939 to 1945, a considerable advancement took place whereby several chemically saturated carbons were produced for war and nerve gases trapping. As of 2014, the estimated amount of AC was assumed to be about 1.1 million metric tons from AC industries with a 10% increase in the projected demand for fresh AC.
- There will be an expected increase in demand for AC in the United States of America (USA) due to the new federal laws directing removal of heavy metals from coal-fed power plants effluent before discharging it into the streams [10, 9].
- It was reported that Low-cost materials, rich in high concentration of carbon and low inorganic contents have been used as raw materials for AC production. Several researches reported a variety of raw materials that can be used to produce AC.
- Some of the widely used are agro-industrial by-products, which are characterized by their renewability, high mechanical strength, cheapness, abundance, as well as low ash contents.
- In fact, several studies have reported the utilization of agricultural wastes biomass residues in AC production such as rice husk as coal, jujube seeds, sawdust, tropical wood, palm shells, durian peel, corn cobs, coconut shell, walnut shells, watermelon, tobacco stems, bean husks, hazelnut shell, banana peels, mangosteen shells and many more. Also, even non-agricultural products like waste-automobile tires were found as cheap sources of AC.
- The maximum adsorptive capacity of AC largely depends on the raw materials' structure and its production processes.

II. LITERATURE REVIEW

In ancient times (1500 B.C), activated carbon (AC) has been used for medicinal purposes. There after the adsorptive powers of AC were discovered in 1773 when Scheele conducted experiments with gases. However in 19th century, the industrial production of activated carbon was well established and gradually it replaced bone char in sugar refining processes[19].

Year	Author	Year Author Significance
1785	Lowitz	Studied the effectiveness of charcoal in decolorizing various aqueous solutions and this appears to be the first systematic account for application of char coal in liquid phase.
1793	Kehl	Discovered that carbon prepared from animal tissues could be used for color removal from solutions.
1805	Delessert	Demonstrated the decolorizing power of charcoal for sugar-beet liquor.
1856	Stenhouse	Prepared the decolorizing chars by heating a mixture of flour, tar, and magnesium carbonate.
1865	Hunter	Recognized the gas adsorption properties of activated carbon prepared from coconut shells.
1913	Wunch	Recognized that the decolorizing capacity of Eponit was greatly increased by heating with zinc chloride.
1931	Kubelka	Interpreted sorption phenomena on active carbon by the mechanism of capillary condensation.

- ❖ **M.A. Tadda, A. Ahsan A. Shitu, M. ElSergany, T. Arunkumar, Bipin Jose, M. Abdur Razzaque, N.N. Nik Daud et. al. 2016...[8]** these are some researchers who do their research about the ACs and search new sources of production and implemented the effectiveness and ability of ACs use in the treatment of wastewater or water and further use in different Industries like; petroleum, fertilizer plants, nuclear, pharmaceuticals, cosmetics, textiles, automobile, and vacuum manufacturing all uses AC. The researchers use the different methods of production of ACs
- Generation of AC reported by many researchers were classified into four main processes which are i)pyrolysis process, ii)physical and iii)chemical activation process and iv)carbonization and steam/thermal activation.
- AC has adsorptive, catalytic, electrochemical and other useful properties.
- AC is found to be effective in adsorption of solutes from aqueous solutions.
- Activated carbon (AC) is used in different states of applications as a reliable adsorbent.
- ❖ **Mona Karniba, Ahmad Kabbanib, Hanafy Holaila, Zakia Olamaa et. al. 2020...[3]** According to their work AC showed the greatest affinity towards nickel with 90 % removal percentage; the shifts in IR wave numbers reflected the bondings between AC and the adsorbed metals as presented by Freundlich isotherm. Silica/AC (2:3) composite showed the greatest removal percentage for 30 & 200 ppm nickel. SEM images revealed that AC was a microparticle with an average size of 25 µm, while silica were nanoparticles having an average size of 12 nm.
- Silica/AC (2:3) composite was the most effective microparticle for nickel removal and it is highly recommended to be used in water treatment for its high adsorptive capacity followed by AC and silica nanoparticles.
- ❖ **Chunguang Yua, XuenaHan et. al. 2015...[2]** Although the application of activated carbon is very wide, it is expensive. At the same time, it needs to complex auxiliary means to improve its adsorption ability. Therefore, in terms of economic reasons, activated carbon can't be used in factories. To sum up, chitosan has a strong adsorption capacity of heavy metals, mainly due to chitosan has a strong hydrophilic, hydroxyl content rich; There are a large number of amino groups has the acid; Adsorption of heavy metals is rich aggregate structure.
- Clay in practical industrial application, expansion coefficient is an issue to consider, because of its special structural characteristics and mechanism of ion exchange, may cause stress.
- ❖ **Syieluing Wong, Norzita Ngadi, Ibrahim M. Inuwa, Onn Hassan et. al. 2018...[5]** It is possible to recover the precious metals from wastewater by adsorption, although such possibility is less studied in the literature. In a study by Tang et al. (2017), ACs were prepared from *T. augustifolia* and *S. matsudana* for adsorption of Pb and Cd. Regeneration of ACs were performed by HCl treatment for 12 h after adsorption of Pb and Cd. Such steps were found to promote desorption of Cd and Pb adsorbed onto the ACs.
- Thus, the recovery of metals from the wastewater can be achieved. Nevertheless, the recovery rate is less than 100% as some of the adsorbed species remained attached to the ACs. Recovery percentage of the metals were also found to decrease with subsequent use in adsorption/ desorption cycle, therefore more through research is needed to gain further insight on the possibility. The research into recovery of precious metals (such as gold, copper) from the wastewater can be rewarding, provided suitable biomass can be found with desirable adsorption and desorption properties.
- ❖ **Jiang Changjia, Cui Shuang, Han Qing, Li Ping, Zhang Qikai et. al. 2019...[7]** Song Jianhui1 and Li Mingruia a widely used adsorbent, activated carbon cannot solve the adsorption problem of wastewater only by improving its properties. The specific surface area of biological activated carbon is large, and the pore structure is very developed, therefore they can effectively adsorb dissolved oxygen and organic matter in water, biological activated carbon as carrier, it can provide a place for microbes to gather, reproduce, and grow.
- Where the environmental temperature and nutritional conditions are appropriate, it can play the role of microbial degradation and adsorption of activated carbon at the same time. [17] Lang, J. studies shows that activated carbon as the carrier of microbial immobilization, the treatment performance of p-phenol is increased by about 30%, it shows that activated carbon has synergistic effect with microorganism, its processing ability and efficiency have been greatly improved

- P.F. et al. studies show that the dosage of O₃ is about 3 mg/L-1, the contact time of O₃ is 15 min, when the contact time of activated carbon empty bed is 9 min, the removal rates of DMP, DBP, D-HP and DOP were 97.6% and 53.8% and 56.0%, respectively, it can be seen that O₃-biological activated carbon process has a good removal effect.
- ❖ **Kalu Samuel Ukanwa, Kumar Patchigolla, Ruben Sakrabani, Edward Anthony and Sachin Mandavgane et. al. 2019...[20]** The chemical activation approach for AC production is widely applied because of its ability to produce AC with a wide range of activating agents under a myriad of processing conditions. The choice of activating agent is contingent on the adsorption target and precursor. Each activating agent has a unique impact on the characteristics and applications of the resultant AC.
 - However, due to the challenges of AC production from biomass, there is a need to develop techniques to achieve industrial-scale production of AC. Microwave systems accelerate the activation process. Bases, acids and ZnCl₂ are generally considered to be particularly effective. Unfortunately, natural chemicals are rarely used for activation despite their potential to reduce secondary contamination which arises when materials like ZnCl₂ and inorganic acids are used, due to the difficulty of effectively removing them by washing. It is clear that microwave treatment is potentially better than conventional approaches, especially in terms of energy saving and process duration; however, to date there are no commercial application of such technology.
 - Despite the existence of larger and larger microwave systems, there remains an urgent need to demonstrate this technology at a commercial or near-commercial scale.
- ❖ **Nikita Chrishel Corda and M. Srinivas Kini et. al. 2018...[21]** Adsorption has been extensively studied and still research is being continued on efficient methods of dye removal. In this review paper various works have been compared and following are some of the findings
 - Most of the agriculture-based AC have good potential for adsorption of cationic dyes
 - On uptake of MB dye varying pH over certain range and stirring did not show any significant changes.
 - Initially for higher dye concentration the uptake of dye by the adsorbent is high and then slowly reaches equilibrium
 - Depending upon the agitation and the process response towards it one can identify the rate limiting step between film and pore diffusion
 - Adsorption isotherms of two and three parameter were used for studies and it was observed that most of them gave good results for Langmuir isotherms.
 - Adsorption kinetics for the adsorption processes were not very satisfying for pseudofirst order kinetics when compared to the second order or intraparticle diffusion.
- ❖ **Shakir A Mir and MushtaqA Rather et. al. 2018...[22]** The absorptive ability and high surface area possessed by activated carbon ability makes it a significant constituent in many industries like petroleum, fertilizer plants, nuclear, pharmaceuticals, cosmetics etc. Also AC has been found to be a good porous material making it a very effective adsorbent of solutes from aqueous solutions. This was suggested to be due to the possession of large specific surface area.
 - AC has also been extensively used for solvents recovery, separation of gases, dye removal from industrial wastewater and as a catalyst in the process of biodiesel production.
 - Other applications are purification of drinking water, treatment of industrial effluents and the groundwater treatment. Adsorption of pesticides and nitrate from surface water can also be achieved by the use of AC.
- ❖ **Joseph Jjagwe, Peter Wilberforce Olupot, Emmanuel Menya, Herbert Mpagi Kalibbala et. al. 2021...[23]** The vast applications of GACs especially in aqueous solutions have increased its demand in many industrial applications. This has increased a search for alternative sources of these carbons to replace commercial GAC that is otherwise expensive and obtained from non-renewable sources. In this review, production of GAC from waste materials has been presented. Production steps such as granulation with and without binders as well as different carbonization and activation methods used to enhance strength and increase attrition resistance of the waste based GAC have been presented. The use of these GACs for water treatment has exhibited a great potential sometimes performing better than the commercial carbons depending on the target contaminant.
 - Much as the optimal conditions for preparation of these carbons has been extensively studied, and there is a dearth of studies on how different preparation pathways affect the use of these carbons in continuous bed



columns as well as regeneration potentials. There is a need for more detailed studies on production, optimization, and applications of waste based granular activated carbon.

III. ACKNOWLEDGEMENT

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IV. CONCLUSION

Conclusively, it is seen from the findings that, the importance and advantages of AC cannot be overestimated as it almost fulfills the needs in every sector that need adsorbent for purification of liquid, gas and solid matters. Consequently, there is a great obligation from the authorities to assist (physically and economically) researchers in finding easy and viable ways to boost the production of AC at best possible quality. These efforts will definitely ensure the protection of our environment that is facing multiple challenges day by day from been contaminated. It will as well serve as a way of creating job opportunities for the youth and the citizens of every nation.

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