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A Review on Activated Carbon Produced from a Suitable Industrial Sludge

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ABSTRACT- Activated carbon has been there with us for centuries. It has wide applications in various industries e.g. in the water-treatment, dye, sugar refining, among others. Constructed wetlands for wastewater treatment have substantially developed in the last decades. As an eco-friendly treatment process, constructed wetlands may enable the effective, economical, and ecological treatment of agricultural, industrial, and municipal wastewater. The present study reviews the recent developments in wetland technology for wastewater treatment from articles published from 2012 to 2022. The papers were searched from Web of Science using the key words constructed wetland and wastewater treatment. Up to 10 articles were selected and a table describes the recent enhancements in wetland treatment technology. Some articles presented notable results, with higher pollutant removal rates or related to some important factors in removal processes. The major enhancement methods for nitrogen, BOD, and COD reduction are hybrid water flow wetland designs and the combination of porous substrates with conventional gravel. Organic substrates, such as coconut shell, wood mulch and rice husk, are a suitable option for the upper porous media. All the activated carbon available in India is imported. Therefore production of activated carbons locally and from locally available materials would be one of the most lucrative and environment-friendly solutions to this as it would transform negative–valued wastes to valuable materials. Thus, the main objective of this research was to prepare activated carbons from suitable Industrial sludge.

KEYWORDS- Activated Carbon, Domestic Wastewater, Constructed Wetland, BOD, COD, Industrial sludge

I. INTRODUCTION

1.1 General Introduction

Activated carbon is used as filter media in waste water treatment reactor, then it will helpful to remove dissolved solids, suspended solids and some dissolved gaseous from a domestic waste water effluent. Large surface area of activated carbon is work as a adsorption media to effectively remove or reduce wide range of dissolved pollutant in domestic waste effluent. Activated carbon is very important chemical has wide application and employed by numerous industries which require absorption of certain gases and vapors in purification, in catalytic chemical reactions, de colorization of vegetable oil and sugar solutions. Activated carbon manufactured from coconut shell is considered superior to those obtained from other sources mainly because of small macro pores structure which renders it more effective for the Coconut shell is used for manufacturing a variety of products of commercial importance including activated carbon. Activated carbon is a non graphite form of carbon which could be produced from any carbonaceous material such as coal, lignite, wood, paddy husk, coir pith, coconut shell, etc. adsorption of gas/vapor and for the removal of color and odor of compounds. The activated carbon is extensively used in the refining and bleaching of vegetable oils and chemical solutions, water purification, recovery of solvents and other vapors, recovery of gold, in gas masks for protection against toxic gases, in filters for providing adequate protection against war gases/nuclear fall outs, etc. Product characteristics H value - 6.5-7.5 Adsorption capacity at % by mass - 45 Moisture (max) - 5% Ash - 5% Hardness - 90 Applications • Granulated activated carbons are used for purification of gases or liquids and are used in a vertical carbon packed column • Activated carbons have been used as carriers for catalyst in the manufacture of chlorinated hydrocarbons. • Activated carbon finds application in the preparation of pills and digestive tablets. Its adsorptive properties are utilized in the treatment of laments of the stomach due to hyper acidity. • In the laboratory, it is used for the production of high vacuum, purification of gases, determination of vapor content in a carrier gas, etc. Global demand National Scenario In India activated carbon industry is of recent origin. There were only one or two manufacturing units in early fifties which have now increased to 50 or even more. But now activated carbon industry is widely spreaded in different parts of the country. Most of the units are in small scale sector. However, based upon the enquiries there are more than 50 units manufacturing activated carbon for selling. They are located in different parts of the country. Most of these units have capacity of more than 100 tonnes. Quite a few units have installed capacity of more than 1,000 tonnes also. Only 10 to 12 units cater to the national market, all other units cater by and large to local or regional market. It is learnt that the total installed capacity of present available was about 75,000 tonnes and production was around 65,000 to 70,000 tonnes which includes purified and regenerated carbon too. International scenarios Estimated demand of activated carbon in developing countries like Bangladesh, Sri Lanka and gulf countries, where industrial development is emerging up is around 134580 MT in 2014 to 2015. The future of beverage industry is very bright. As the demand for activated carbon from this industry is likely to increase rapidly the estimated to be 15 percent annum and accordingly estimated demand are around 12790 in 2010 to 2011. Activated carbon is also being used in nuclear plants and laboratories for containment of many radioisotopes. Since the applications and demand of activated carbon is immense therefore the potential of the product is excellent. It is one of the imperative fields to endeavor.

Activated Carbon is an essential substance for many industrial activities. For instance, bleaching agent (in sugar factory) and for water filtration. Most of the Activated Carbon for industrial activities is being imported from other countries. However, there is no sufficient amount of production to satisfy the need in our country and the demand for Activated Carbon in the market is high. So, to satisfy the demand the Activated Carbon is being produced using solid waste Rice Husk. The purpose of this project is the preparation of Activated Carbon using a suitable rice husk. The Activated Carbon produced from Pyrolysis of rice husk was chemically activated with activating agent sodium hydroxide (NaOH). The chemically activated carbons were characterized by measuring yield percentage and bulk densities. The activated carbon produced from rice husk at different activating temperature of 650ºC, 700ºC and 800ºC exhibit a yield percentage of 48.2%, 47.65% and 45.95% respectively and corresponding bulk densities were 0.2 g/ml, 0.16 g/ml and 0.117 g/ml respectively. Proximate analysis also performed for precursor selection to choose the appropriate precursor. The quality of activated carbon is highly proportional to the dehydration rate of the sample and also on the process of removal of the volatile substances present in the precursor. According to proximate analysis, rice husk has a volatile matter of 68.06%, ash content 0.952%, fixed carbon content 20.988% and moisture content of 10%. This contributes to a total volatile content (easily escapable components) of about 68.06%. The proximate analysis of rice husk also reveals that the selected rice husk has good carbon content which is 20.988%. Therefore, proximate analysis served as an evidence for choosing rice husk as the precursor. Finally, a preliminary material and energy balance on pyrolysis or carbonization was performed.

The purpose of this project is to prepare a cheap, cost efficient, simple, affordable and sustainable treatment of grey water for household purposes. Activated charcoal and sand filters were evaluated for the purpose of grey water filtration. The treated grey water can be used for non-potable purposes such as irrigation, car washing, urinals and toilet flushing, fire protection, etc. To achieve this objective samples were collected from households and series were collected from households and series of treatments such as pH, TDS, Alkalinity, BOD, COD were carried out. We have compared the results of effluent (chemical and physical properties) from slow sand filtration and slow sand filtration aided with Activated Charcoal filter. Thus, from the results an attempt has been made to prepare a household model for the treatment of Grey water by using activated charcoal and then reusing it for various purposes. This project will help to understand a new approach of an environmental friendly household filtration techniques. Wastewater is any water that has been contaminated by human use and activities. Wastewater is used water from any combination of domestic, industrial, commercial or agricultural activities and any sewer inflow or sewer infiltration. Therefore, wastewater is a after product of domestic, industrial, commercial or agricultural activities and use. Also there is scarcity of water situation going on since ages in the entire country. Therefore there is a need to make into use the waste water by treating it by such means that another system should not get disturb and also those means should be affordable and easy to apply in practical work. The issue of greywater management – which is defined as all sources of domestic wastewater excluding toilet wastewater – is gaining more and more importance, especially in developing countries where improper wastewater management is one of most important causes for environmental pollution and fatal diseases. In recent years not only the threats of improper greywater management have been recognised; there is an increasing international recognition that greywater reuse, if properly done, has a great potential as alternative water source for purposes such as irrigation, toilet flushing and others.

II. LITERATURE REVIEW

2.1 Activated Carbon

Activated carbon includes a wide range of amorphous carbon-based materials prepared to exhibit a high degree of porosity and an extended interparticulate surface area. It is also a common term used for a group of adsorbing substances of crystalline form, having large developed internal pore structures that make the carbon more adsorbent.

2.2 History of Activated Carbon

The use of carbon extends so far back into history that its origin is impossible to document. The first known use of activated carbon dates back to the Ancient Egyptians as early as 1500 B.C. who utilized its adsorbent properties for purifying oils and medicinal purposes. Charcoal was used for drinking water filtration by ancient Hindus in India. Centuries later, the early ocean-going vessels stored drinking water in wooden barrels, the inside of which had been charred. However, by modern definition the carbon used in these applications could not truly be described as "activated". By the early 19th century both wood and bone charcoal was in largescale use for the decolourization and purification of cane sugar. The first documented use of activated carbon in a large scale water treatment application was in 19thcentury England, where it was used to remove undesirable odours and tastes from drinking water. In recent years, the use of activated carbon for the removal of priority organic pollutants has become very common. Today, hundreds of brands of activated carbon are manufactured for a large variety of purposes. The largest market for activated carbon is currently in the municipal water purification industry, where charcoal beds have been used for the dual purpose of physical filtration and sorption. In fact, activated carbon filters are used today in drinking water treatment to remove the natural organic compounds (i.e. tannins) that produce carcinogenic chlorinated by-products during chlorine disinfection of water. In wastewater treatment, activated carbon is usually used as a filter medium in tertiary (later) treatment processes. In these applications, carbon filters are usually quite effective in removing low concentrations of organic compounds, as well as some inorganic metals. In addition to its drinking water and wastewater treatment applications, activated carbon is used today for many other purposes. Some other common uses are: corn and cane sugar refining, gas adsorption, dry cleaning recovery processes, pharmaceuticals, fat and oil removal, electroplating, alcoholic beverage production, and as nuclear power plant containment systems.

2.3 Structure of Activated Carbon

In order to explain the capabilities of activated carbon, an appreciation of its structure is most useful. Much of the literature quotes a modified graphite-like structure; the modification resulting from the presence of micro crystallites, formed during the carbonization process, which during activation, have their regular bonding disrupted causing free valencies which are very reactive. In addition, the presence of impurities and process conditions influence the formation of interior vacancies, in the microcrystalline structures. Such theory generally explains pores as the result of faults in crystalline structures. However, more recent research studies provide a more feasible explanation of the carbon structure. The generally accepted graphite-like structure theory falls down since the hardness of activated carbon is not in keeping with the layered structure of graphite. Furthermore, the manufacturing conditions are different; in particular the temperature range utilized for activated carbon production is lower than that required for graphitization. Supporters of the graphite-like structure generally only explain the modified microcrystalline structure and ignore photographic and other methods of examining the residual macro structure. High magnification electron scanning microscopy, at 20,000x magnification, has revealed the presence of residual cellular structures. These were previously unseen and unsuspected, except in the case of woodbased activates which have sufficiently open structures visible to the naked eye. Cellular units are built from sugars, the most important being glucose. Sugars ultimately will build to cellulose (the most important single unit in cellular construction) and cellulose polymers cross-link to form the wall of individual plant cells. Glucose units are wound into very tight helical spirals and under polarized light, these exhibit anisotropy - demonstrating the presence of crystalline structures. Although not as yet proven, it has been postulated that in the areas of maximum strain in cellulose chains it is conceivable that smaller crystalline units could be produced. In addition to cellulose, other materials also exist in cell wall structure. Hemi-cellulose, which undergoes degradation more easily than cellulose and Lignin (the structure of which is still unproven) also exists and this is the most resistant to oxidation. Most theories attribute the structure of activated carbon to be aromatic in origin, thus, allowing the carbon structure itself to be described as aromatic in order to explain active centres, etc. Structures of the size of cell dimensions obviously do not influence physical adsorption but illustrate that the only material available for oxidation lies within the cell walls themselves. Final activates consist almost entirely of elemental carbon together with residual ash which, in the case of wood and coconut, originate from minerals within the vessels of living tissues; silica being the only constituent actually incorporated within the cell wall tissue matrix. The ash content of coal is of different composition and due to intrusion of inorganic materials during coalification. Thus, the overall structure consists of a modified cellular-like configuration with varying ash components depending on the particular raw material. The cellular-like structure theory offers a logical explanation for the differences in apparent density between activates of wood, coal and coconut. Wood activates have a very open structure with thin wall cells whereas coconut activates show very thick walls with many pits. It is known that the carbonization and activation processes destroy, to varying degrees, intercellular walls and sieve plates between cells. The end result on wood is a very open, sponge-like macrostructure seriously reducing the probability of adsorbate contact with cell walls. Activation of coconut produces a composition of rod-like cells in very close contact and large surface cavities are formed by destruction of dividing walls but these are shallow and do not extend through the activates granule. The coconut activates thus differ significantly from wood activates in mechanical strength and density. Coconut activates exhibit extensive micro pore volume, whereas wood activates have a definite trend to Mesopores/macro pores and a corresponding change in their basic properties. In the case of coal based carbons, pre-treatment of the raw coal is necessary in order for it to be processed, since raw coal swells during heating to produce coke-like structures. Control of this is achieved by first grinding the raw coal and mixing it with various additives, such as pitch, before it is introduced to the activation furnace.

2.4 Wastewater

"Wastewater" Definition

The term "wastewater" refers any water that has been used or polluted, and contains waste products. Wastewater is approximately 99% water; only 1% is a mixture of suspended and dissolved organic solids, detergent, and cleaning chemicals. "Sewage" is one kind of wastewater. It includes household waste liquid from toilets, baths, showers, kitchens, sinks and so forth that is disposed of via sewers. Sewage treatment, or municipal wastewater treatment, is the process of removing contaminants from wastewater and household sewage. It includes physical, chemical, and biological processes to remove organic, inorganic and biological contaminants. The typical composition of municipal wastewater (after pretreatment) most often treated in CWs contains suspended solids, organic matter, and in some instances, nutrients (especially total nitrogen) and heavy metals, as shown in Table 2 (**Tchobanoglous & Burton, 1991**). Domestic sewage wastewater typically contains 200 mg of suspended solids, 200 mg biochemical oxygen demands, 35 mg nitrogen, and 7 mg phosphorus per liter **(Volodymyr, Sirajuddin, & Viktor, 2007).**

Table 2.1 : Contaminations Concentration in the Typical Untreated Domestic Wastewater

Parameter	Unit	Weak (Concentration)	Medium (Concentration)	Strong (Concentration)
TS	Mg/L	350	720	1200
TDS	Mg/L	250	500	850
TSS	Mg/L	100	220	350
BOD	Mg/L	110	220	400
COD	Mg/L	250	500	1000
TN	Mg/L	20	40	85
TP	Mg/L	4	8	15
Total Coliform	No/100mL	10^6-10^7	$10^7 \sim 10^8$	$10^7 \sim 10^9$

2.5 Wastewater Reuse and Reclamation

During the last century, the increasing demands for freshwater coupled with environmental concerns about the discharge of wastewater into ecosystems and the high cost and technology requirements of wastewater treatment have spurred processes in water reclamation and reuse. Early development stems from the land application for the disposal of wastewater, following the admonition of Sir Edwin Chadwick—"the rain to the river and the sewage to the soil" **(National Research Council of the National Academies, 1996, p. 17).** Such land disposal schemes were widely adopted by large cities in Europe and the United States in the 1900s. With the development of sewerage systems, domestic wastewater was firstly considered to be reused by farms. California was the pioneer in wastewater reuse and has the most comprehensive regulations pertaining to the public health aspects of reuse. By 1910, 35 California communities were using sewer water for irrigation (Recycled Water Task Force, 2003). In 1918, the California State Board of Public Health promulgated the initial Regulation Governing Use of Sewage for Irrigation Purpose, pertaining to irrigation of crops with sewage effluents. In 1929, the city of Pomona, California, initiated a project using reclaimed wastewater for the domestic irrigation of lawns and gardens **(Ongerth & Harmon, 1959)**. In 1965, the Santee, California recreational lakes, supplied with reused wastewater, were opened for swimming. Today, as more advanced technologies are applied for water reclamation, the quality of reclaimed water can exceed conventional drinking water quality based on most conventional parameters. Water reclamation or water purification processes could technically provide water of almost any quality desired **(Asano, 1998).**

2.6 Conventional Wastewater Treatment

The conventional wastewater treatment process consists of a series of physical, chemical and biological processes. Typically, treatment involves three stages, called primary, secondary and tertiary treatment.

2.6.1 ***Primary treatment*** is used to separate and remove the inorganic materials and suspended solids that would clog or damage the pipes. Primary treatment consists of screening, grit removal, and primary sedimentation. Screening and grit removal may also be called "preliminary treatment." Large debris, such as plastics, rags, branches, and cans are removed by the screens, while smaller coarse solids, such as sand and gravel, are settled by a grit chamber system. Then wastewater is moved into a quiescent basin, with a temporarily retention; the heavy solids settle to the bottom while the lighter solids, grease and oil float to the surface. The settled and floating pollutants are removed by sedimentation and skimming, with the remaining liquid then discharged to undergo secondary treatment. Typically, about 50% of total suspended solids (TSS) and 30% to 40% of BOD are removed in the primary treatment stage **(Nelson, Bishay, Van Roodselaar, Ikonomou, & Law, 2007).**

2.6.2 Secondary treatment removes dissolved and suspended biological matter. Typically, up to 90% of the organic matter in the wastewater can be removed through secondary treatment by a biological treatment process **(U.S. EPA, 2004b).** The two most common conventional methods used to achieve secondary treatment are attached growth processes and suspended growth processes. In attached growth (or fixed-film) processes, the bacteria, algae and microorganisms grow on a surface and form a biomass. Attached growth process units include trickling filters, biotowers, and rotating biological contactors. In suspended growth processes, the microbial growth is suspended in an aerated water mixture. The most common of this type of process is called "activated sludge." This process grows a biomass of aerobic bacteria and other microorganisms that will breakdown the organic waste.

2.6.3 Tertiary treatment is sometimes defined as advanced treatment; it produces a higher-quality effluent than do primary and secondary treatment in order to allow discharge into a highly sensitive or fragile ecosystem (estuaries, low-flow rivers, coral reefs, and others). The purpose of tertiary treatment is to provide a final treatment stage to raise the effluent quality to the desired level. This advanced treatment can be accomplished by a variety of methods such as coagulation sedimentation, filtration, reverse osmosis, and extending secondary biological treatment to further stabilize oxygen-demanding substances or remove nutrients. As wastewater is purified to higher and higher degrees through such advanced treatment processes, the treated effluent can then be safely and appropriately reused. Before the treated wastewater is discharged, ***a disinfection process*** is sometimes required. Water systems add disinfectants to kill pathogenic microorganisms. The purpose of disinfection in the treatment of wastewater is to substantially reduce the number of microorganisms in the water to be discharged back into the environment, and it is almost always the final step in the treatment process regardless of the level or type of treatment used. Common methods of disinfection include chlorine, and ultraviolet light. The treated water can be discharged into a stream, river, lagoon, or wetlands, or it can be used for landscape irrigation. If it is sufficiently clean, it can also be used for groundwater recharge or agricultural purposes.

2.7 Research Article

[1] "Use of Pervious Concrete as Gravity Filter" By:-Ninad Oke, Parth Choksi, Amey Naik, Nikita Mahapatra, ASABE Conference Paper, Publishing year :- Nov 2014.

In this study the usage of pervious concrete for filtration purpose is highlighted. It is well known that pervious concrete is traditionally used in parking areas, areas with light traffic, residential streets, pedestrian walkways, and however not much research has been done on its effectiveness to be used for filtration process. In the water purification process rapid sand filter is provided after sedimentation process. The turbidity of water entering the rapid sand filter is around 25-100 NTU depending on the season of the year. Conventionally, the filter media used is graded sand. This study was conducted to see the feasibility of using pervious concrete as a filtration media. The pervious concrete blocks used had sixteen different combinations in triplicate. The combinations used were having variability in type of cement, water cement ratio and thickness. A reduction of 69.8% turbidity for initial turbidity of 25 NTU and 66% reduction for initial turbidity of 100 NTU was observed. A 97 and 99 % MPN removal for 25 and 100 NTU of initial turbidity was observed.

[2] "Design of Grey Water Treatment Units" By:-M.Seenirajan, S.Sasikumar, Erlin Antony, International Research Journal of Engineering and Technology (IRJET). Publishing Year :- Volume:05 Issue:05 May 2018.

In this paper we have studied about composition and characteristics of grey water and using this information design of treatment units were easy. Treating wastewater will surely reduce the effects of its harm and thus increasing its usability. Once undergone through the procedure of proper treatment, you will no longer receive any bad odours. The water, thus obtained, is clean and safe for use. Grey water can replace drinking water for irrigating gardens or lawns especially during drought periods.

[3] "Efficiency of Slow Sand Filter in Wastewater Treatment" By- Teena Ann Thomas and K. Mophin Kani, International Journal of Scientific & Engineering Research. Publishing Year- Volume 7, Issue 4, April-2016.

Slow sand filtration is a technology that has been used for potable water filtration for hundreds of years. It is a process well-suited for small, rural communities since it does not require a high degree of operator skill or attention. As its name implies, slow sand filtration is used to filter water at very slow rates. The typical filtration rate is at least fifty times slower than for rapid rate filtration. It was observed that the reduction efficiency of turbidity is about 70% and the reduction in pH and electrical conductivity is also noticeable. Thus it can be concluded that the slow sand filter is efficient in treating wastewater from a particular source.

[4] "A Review on Pervious Concrete" By- Vr.Bharanidharan, K.Ashok Kumar, M. Samuel Thanaraj, International Research Journal of Engineering and Technology (IRJET). Publish year :-Volume-6, Issue-3, March 2019.

Pervious concrete is a cost-effective and environmental friendly solution to support sustainable construction. It's ability to capture storm water and recharge ground water while reducing storm water runoff enables pervious concrete play a significant role. Due to its potential to reduce the runoff, it is commonly used as pavement material. The smaller the size of coarse aggregate should be able to produce a higher compressive strength and at the same time produce a higher permeability rate. The mixtures with higher aggregate/cement ratio 8:1 and 10:1 are considered to be useful for a pavement that requires low compressive strength and high permeability rate. The ideal pervious concrete mix is expected to provide the maximum compressive strength, and the optimal infiltration rate. Pervious concrete is one of the leading materials used by the concrete industry as GREEN industry practices for providing pollution control, storm water management and sustainable design.

III. PROPOSED METHODLOGY

Precursor (raw material) selection for the production of activated carbon was obviously the first step of the project. Conventionally, activated carbon is produced from carbonaceous source material such as wood, peat, coal, and wastes of vegetable origin (e.g. nutshells, fruit stones). Today, one promising approach for the production of cheap and efficient activated carbon is the reuse of waste sludge, such as bio solids produced at municipal or industrial wastewater treatment facilities. The usage of waste sludge is especially important due to its mass production and resulting occupation of valuable landfill space.

The two types of industrial sludge available as choices for precursor were:

1. ∟ Rice husk
2. ∟ Paper sludge

To decide the superiority of a precursor over the other characterization of the precursor was done using various methods like:

1. CHNS elemental analyser
2. Proximate analysis

IV. CONCLUSION

Activated carbon is a non-graphite form of carbon which could be produced from any carbonaceous material. Activated carbons are increasingly used as the economic and stable mass separation agent for the removal of surfactants to raise the final product quality many industrial processes. Activated carbons also play an important role in many areas of modern science and technology such as purification of liquids and gases, separation of mixtures and catalysis. Activated carbon are specially treated material which undergoes the chemical process to increase the adsorption capabilities of the material. Various material are used for the activated carbon which includes coal (anthracite , bituminous, sub-bituminous and lignite), coconut shells, wood(both soft and hard). Some materials have also been evaluate like wall- nut shells, olive stones and palm kernels. In our project we have used the coconut shells as the activated carbon material as there is a abundance of coconut farming in konkan area. The activated carbon using coconut shell will be economical in preface as the filter media with the slow sand filter at house hold level also. Activated carbon is a non-graphite form of carbon which could be produced from any carbonaceous material. Activated carbons are increasingly used as the economic and stable mass separation agent for the removal of surfactants to raise the final product quality many industrial processes. Activated carbons also play an important role in many areas of modern science and technology such as purification of liquids and gases, separation of mixtures and catalysis. The main objective of the study is to produce activated carbon from dry coconut shell and to treat the domestic waste water and to recycle the treated water for home gardens. The higher purity, negative cost, high rate of production and strong carbonaceous structure of industrial sludges proves to be a precursor for carbon production. This research will pave way for the recycle and reuse of waste water that could further reduce the level of water pollution.

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