

Study and Application of Various Activated Carbons and Ash used in Water Purification Techniques: A Review

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Abstract

Water pollution is increasing due to the different factors such as population growth, large-scale urbanization, deforestation, and unethical activities in the river or other sources of water. Various experts have been working in the field of the preparation of activated carbon from renewable energy including cost-effective technologies and products in an eco-friendly manner for various applications. This review article discusses methodologies utilized by various experts for the preparation of activated carbon for the abatement of water pollution. Biomass such as coconut shell, Moringaoleifera seed, Peanut shell, Pomegranate peel, Rice husk, Lemon shell, Banana peel, and Orange Peel are found extremely helpful in the field of treatment of the contaminated water. The reviewed literature showed that the Biomass can be isolates pollutants from contaminated water through physical, mechanical, and biological techniques and removes various physicochemical pollutants such as pH, color, DO, turbidity, conductivity, turbidity, chloride, fluoride, TSS, TDS, BOD, COD, nitrate, phosphate, and heavy metal, etc. from contaminated water.



Article History

Received: 26 May 2020
Accepted: 2 November 2020

Keywords

Activated Carbon;
Ash;
Cost-Effective;
Contamination;
Treatment;
Water.

Introduction

To keep all living things alive on the earth, the amount of water in the human body always has to be kept balanced and adequate which is 55% to 78% in range.¹ Sitting men and women under normal conditions needed 2.9 and 2.2 liters of water every day for enough hydration.² Similarly, the separate advice has also been made for the stage of child,

pregnancy, and lactation. Women and children at high temperatures may require up to 4.5 liters of water every day.³ World Health Organization WHO (1971) describes that healthiness of water means non-appearance of inorganic solids, pathogens and suspended solids.^{50, 51} Impurity of water with contaminated particles is a serious problem for sustaining the standard and sanitation of water.⁵

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Doi: <http://dx.doi.org/10.12944/CWE.15.3.03>

It is Mentioned in The Indian Constitution that, water is a friendly element for all backward and non-backward religion and casts Article 15 (2) (b).⁵²

Anciently, the utilization of activated carbon was started as sorbent charcoal which was discovered by the Chinese and Roman Empire and possibly further.^{4, 24} The Romans understood that the charcoal has a property to purify the water. Although this long history of charcoal utilization for contamination, it takes more than 3000 years to enhance the charcoal for the removal of explicit contaminants.^{4, 24} early in the 20th century, the first production plant of Activated Carbon was appointed in Germany intentionally for the industry of sugar refining. Latterly, some portion of the plants appears to manufacture Activated Carbon for processes of contaminated water treatment.⁶

There are several methods, likewise, membrane filtration, deionization, adsorption, reverse osmosis, and ion exchange are being utilized to make wastewater appropriate for supplementary utilization.^{7, 8} Adsorption utilizing activated carbon is viewed as one of the most systematic and cost-effective methods.^{8, 9, 10} Due to activated carbon has an enormous specific surface zone and developed micropores, the activated carbon has tough adsorption and a huge capacity of adsorption.¹¹ Recently, there is an extraordinary enthusiasm found for a cheap and effective option in contrast to the activated carbon due to there are various issues with the recovery of utilized activated carbon.¹² Activated carbon is generally utilized as an adsorbent in the industrial procedures which has been made a uniform and microporous structure and high surface radiation strength. The procedure for preparing high efficiency activated carbon is yet not been extremely investigated in developing countries.¹²

Currently, the scenario of Water pollution has arrived at the shocking stage. The quality of water in most aspects of the world has Reduced.¹³ various studies have reported the biomass-based activated carbon utilized in the purification of wastewater. Such as Coconut Shell can reduce the concentration of contaminants like Turbidity and Hardness,¹⁴ Moringaoleifera Seed removes concentration of Turbidity, Conductivity, Total Coliform, pH, acidity,

Alkalinity, and Chlorides,¹⁵ Peanut Shell reduces the concentration of pH, Heavy metals like. Cu, Ni, Zn, BOD, COD, and TSS,¹⁶ Pomegranate Peel reduce the concentration of Nitrate and Phosphate,¹⁷ Rice Husk Ash reduce the concentration of pH, Conductivity, TDS, Color, Turbidity, Color, Hardness, and Fluoride,¹⁸ Lemon and Banana Peel can reduce the concentration of Turbidity, BOD, Hardness, DO and pH¹⁹ and Orange peels reduces concentration of COD and TSS.⁸

This review covers the usage of Activated Carbon and Ash (Table 1) for reducing contaminants from water, and highlighted publications are mostly from the last 8 years. Efforts are also taken to differentiate between various sample parameters assessed from contaminated water and reduction capacity using various biomass Activated carbon and Ash. This review focuses on applications of AC though it covers previous recorded studies and analysis, so it may play the principal role in the field of production of Water filter and water filtration methods.

Table 1: Substitutive bio mass suggested for the production of activated carbons and Powder.⁴¹

Rice Husk Ash	Bark
Beat-sugar sludges	Moringaoleifera Seeds
Molasses	Rice hulls
Nut shells	Coffee beans
Olive stones	Coconut shell
Peanut Shell	Coconut coir
Cereals Palm	Tree cobs
Pomegranate Peel	Cottonseed hulls
Corn Cobs	Coal
Bagasse	Refinery waste
Fruit pits	Graphite
Lemon and Banana Peel	Sunflower seeds
Tea leaves	Wheat straw
Lignin Wood	Lignite

Various Type of Biomass

Activated carbons and Powders have been produced from Coconut Shell,^{14, 32} Moringaoleifera Seeds,¹⁵ Peanut Shell,¹⁶ Pomegranate Peel,¹⁷ Rice Husk Ash,¹⁸ Lemon and Banana Peel¹⁹ (Table 1). Coconut shell (35,000 tonnes/year), Wood (130,000 tonnes/year), lignite (50,000 tonnes/year), peat (35,000

tonnes/year), and coal (100,000 tonnes/year), are most often used.^{40, 41}

Activants for activating the carbon

Activated carbons are generated by carbonization implementing steady substrate heating without air less than 600°C and this removes volatiles.⁴¹ Treatment with oxidizing mediums like O₂, C₆₀ or vapors, at raised temperature or with chemical

activants like ZnCl₂, KOH, FeCl₃, H₃PO₄, H₂PO₄, H₂SO₄, KCNS, KNO₃ etc. (Table 2) Concludes the activation process.^{45, 46, 41} The merit of chemical activation is the bottom temperature essential Chemical activation offers top yields since burning of char is not that necessary.⁴¹ Primary activation discards remained catalyst, which may be recaptures and reused. Some precious biomass with activants and their other conditions are listed in Table 2.

Table 2: few chemical activants to produce activated carbon from biomass

Sr. No	Biomass	Activant	References
1	Coconut Shell	ZnCl ₂ , KOH, FeCl ₃	14, 32
2	Moringaoleifera Seeds	-	15
3	Peanut Shell	H ₃ PO ₄ , KNO ₃	16
4	Pomegranate Peel	H ₃ PO ₄	17
5	Rice Husk Ash	FeCl ₃ , NaOH, AS ₂ O ₃	18
6	Lemon and Banana Peel	-	19
7	Orange peels	H ₃ PO ₄	8

Applications of Activated Carbon

Over the last thirty years there has been expanding worldwide concern over the societies health effects attributed to environmental pollutions.^{20, 21} Recently, the usage of AC in water treatment methodology has increased enormously due to its micro porous structure and high surface area which leads to removes contaminants from polluted water and it plays an essential role to decline several pollutions.²² Fig.1 shows the basic applications of activated carbon.

Worldwide few markets are expanding to the interest of activated carbon. The yearly net estimation of the activated carbon marketplace is assessed at \$3.0 billion (USD).^{23, 24} Powdered activated carbon represents roughly 50%, Granular activated carbon (GAC) was roughly 30% of the complete market with polymer-covered, and impregnated-activated carbons representing the remaining 20%.^{23, 24} Some heavy metal ions like lead, cadmium, and mercury presents in contaminated water are extremely hazardous and cancer-causing.²⁵ Activated carbon is the best source and can remove the toxins which present in the form of heavy metals from contaminated water, Also Activated carbon can act

as a treatment material to air scrubbing mechanism for the elimination of vapors and gases in the commercial circumstances.²⁵ So as discussed above AC offers perhaps the best means for managing air and water contamination issues, which cause crucial health hazards.^{26, 27} every activating factor uniquely affects the properties and applications of the resultant of AC.²⁷ though, because of the challenges in the field of AC generation from biomass, there is a requirement to develop methods to fulfill industrial-scale manufacturing of AC.²⁷ Microwave setup accelerates the activation process. Acids, Bases, and ZnCl₂ are commonly viewed as especially effective.²⁷

various researchers recorded the production of activated carbon from sustainable resources by utilizing cost-effective techniques and materials for different applications in an eco-friendly way which has been accounted for that the industrial, domestic, and agricultural waste material is an acceptable parent for producing activated carbons.²⁸ The requirement for activated carbon has developed in several industries, mostly in the cosmetics, pharmaceutical and medical industries (Fig.1).²⁹ This insists us to deliberate a large number of waste materials ready for the production of activated carbon.²⁹ In the late 1930s

decade without a doubt, AC increased enormous force and prominence in the industrial zone for both fluid and gaseous aspects applications.³⁰ From 1939 to 1945, significant progress occurred whereby a few chemically saturated carbons were created for nerve gas trapping and war.^{6,30}

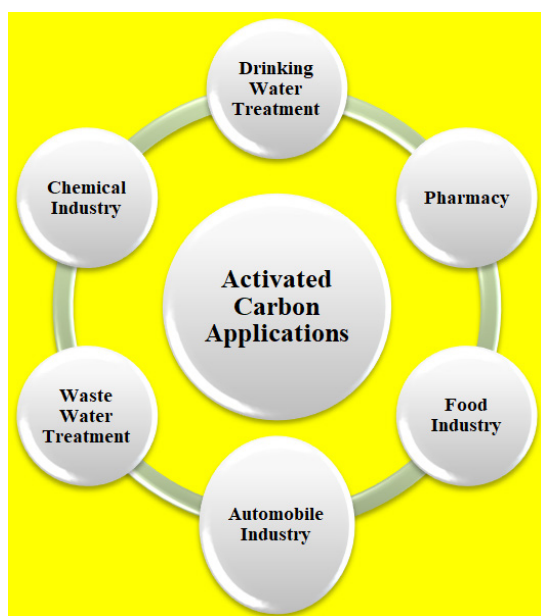


Fig. 1: Applications of Activated Carbons

Some Recorded Material and Methods by various Researchers

A) Coconut Shell Activated Carbon (CSAC): Preparation for making CSAC

Fig. 2 shows a flowchart diagram for the preparation method of Coconut Shell Activated Carbon.¹⁴

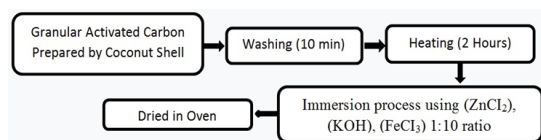


Fig. 1: flow chart for the Preparation of activated carbon made up from Coconut Shell

Removal of turbidity

Three correlative samples, with a volume of 500 ml were examined.¹⁴ Turbidity meter used to check fluctuating turbidity from the water sample. The

Decrease in turbidity was increased in the manner of ACFe (1) <ACFe (3) <ACFe (2).¹⁴ observations recorded that the turbidity of ACFe(2) decreased since it had an extra active site and larger surface area to adsorb the particles from sample especially compared to ACFe(1). Accordingly, increase the dose of activated carbon expanded the surface area and active site for the adsorbent cycle to occur.³¹ additionally, decline of turbidity also higher than ACFe (3).¹⁴ It recorded that the rise in AC dosage around 200 gm can decline in turbidity due to increased in attrition for molecules that lead to a higher dosage of fine particles, hence dosage of 200 gm can remove the concentration of turbidity using 30 mL/s flow rate though it is recorded that FeCl₃ is the best removing agent to decrease metal content and turbidity from the contaminated water sample.¹⁴ While an increase in the level of carbon dosage by more than 200 gm and 30 mL/s water flow rate would still not raise the CSAC's reduction capacity for turbidity due to the attrition rate, but this could decrease further metal content.¹⁴ For a pleasant taste of water, KOH is the best choice and it enhances the taste as well it kept Colorless and odorless property constant.¹⁴ WHO indicate that the turbidity of drinking water should not be greater than 5 NTU and it should preferably below than 1 NTU⁵³

Removal of Hardness

Hardness from water is so essential general water quality problem the that world is facing.⁵⁴ Using Granular CSAC standard particle size of 2.26 mm in diameter the hardness in water (pre and post treatment) was examined using EDTA titrant³² as described.³³ CSAC used without any advance crushing and screening.^{32, 33} Fourier Transform Infrared (FTIR) assessment utilized to assess the functional group of the surface of adsorbents using the FTIR spectrometer wavelength in range 500 to 4250 cm⁻¹, and Surface morphology of the CSAC identified using Scanning Electron Microscopic (SEM) method (FE-SEM, HITACHI S-4800).³² It is recorded that the FTIR technique is an effective method for defining the signature functional groups which play an essential role to adsorb hardness.³² as well; pH of the solution is an essential factor in the adsorption process.³⁴ results shown that the elimination of water hardness mostly depending on the pH of the solution due to variations in the concentration of hydrogen ions which impact the

number of binding sites on the adsorbent surface of the metal ions.³²

The Initial pH of the collected samples ranges 2-12.³² at 7.2 pH the hardness increases from 2 to 4 mg/L. This happens due to competition among hydroxyl H^+ ions. At this stage, Ca reduces the surface of CSAC.³⁵ recorded performance at 5-10 pH found almost unchanged.³² this pattern produces in the bulk solution nearly in uniform amounts of H^+ and OH^- ions which influences the amplitude of the adsorbent that rendering favorable to adsorb further ions.³² recorded pH 10-12 reported an exponential increase in removal rate. This happens due to an increase in the composition of hydroxyl ions (OH^-) in solution which, increases adsorbent negativity. The maximum removal percentage recorded 94% which obtained at the pH of 12.³²

At adsorbent dose 0.06 to 0.3 g/cm³ the efficiency of reduction increases with CSAC dose up to 0.24 g/cm throughout the analysis whereas more increases in dose results into minimum adsorption capacity.³² Maximum adsorption is achieved over a dose of adsorbent and thus the quantity of ions remains unchanged although with the addition of an adsorbent.³⁶ For this cause, the adsorption is noticed to be constant above 0.24 g/cm³.³² So the CSAC is an impressive and operative element for water softening. Coconut shells are locally accessible, mostly in various coastal regions where

hardness problem is obtaining. CSAC adsorbents are relied upon to be economically permissible for the elimination of hardness from groundwater. Langmuir adsorption isotherm model recorded the concentration of hardness particles using CSAC is acceptable. Even though the elimination at pH 12 is high, this will involve the usage of other pH improving indicators which will form the process noncommercial and it leads to the commencement of chemical contaminants present in softened water.³²

Moringaoleifera and Tamarind Seeds powder Preparation for Moringaoleifera and Tamarind Seeds powder

Dried Moringaoleifera seeds were collected when they were completely ripened. Wings and coat from seeds are evacuated fine powder and sieved with fine mesh.¹⁵

Procedure for Sample Analysis

A common treatment plant was used to fulfill the batch coagulation procedure for the treatment of water samples.¹⁵ it adjusts as a flocculation tank, overhead tank, collecting tank and sedimentation tank.¹⁵ liters sample taken, and various quantity of coagulant dosage was added in the flocculation tank succeed by fluctuation in pH. Mixing done in 1-60 minutes then samples approves to settle for 10-60 minutes. Treated samples were examined to check the concentration of turbidity and alkalinity¹⁵ (Fig. 3).

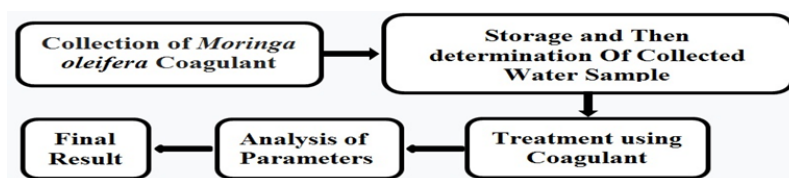


Fig. 3: Methodology of recorded analysis

Concentration of pH

The Initial value of pH measured while analyzing the sample shows 8.8 pH.¹⁵ At coagulant dosage of 300 mg/L and 350 mg/L of Moringaoleifera seed powder recorded 7.2 pH and the reduction efficiency found to be 18.8% for both Moringaoleifera and Tamarind seed powder.¹⁵ At coagulant dosage of 300 mg/L and 350 mg/L of combined Moringaoleifera and Tamarind seed Powder recorded 7.1 of pH and reduction efficiency is 19.31%.¹⁵

Removal of Turbidity

The optimum dosages range between 100-350 mg/L used and 250 mg/L of them became the most effective dose.¹⁵ the optimum coagulant dose of 250 mg/L of Moringaoleifera seed reduced turbidity to 04 NTU. Furthermore, the optimum coagulant dose of 250 mg/L of combined Moringaoleifera and Tamarind seed powder reduced turbidity to 03 NTU.¹⁵ initial concentration of turbidity measured shown 320 NTU. Furthermore, dosages range

between 100 mg/L to 350 mg/L analysed¹⁵ and 250 mg/L recorded the most effective dose.¹⁵ The coagulant dose of 250 mg/L from *Moringaoleifera* seed powder decreases turbidity up to 6 NTU and reduction efficiency found 98.12%.¹⁵ at 250 mg/L dose mixture of *Moringaoleifera* and Tamarind seed powder decreases turbidity up to 4 NTU and the reduction efficiency found 98.75%.¹⁵

Removal of Alkalinity

The Initial concentration of alkalinity has shown 245.50 mg/L.¹⁵ total dosages of *Moringaoleifera* and Tamarind seed powder were used between 100 mg/L -350 mg/L and the dose of 350 was became the most effective dose.¹⁵ coagulant dose of 350 of *Moringaoleifera* seed powder decreases the Alkalinity up to 88.75 mg/L whereas the reduction efficiency is 63.84%.¹⁵ 350 mg/L Mixture coagulant dosage of *Moringaoleifera* and Tamarind seed powder decreases alkalinity concentration to 80.¹⁵ mg/L where reduction efficiency found 67.35%.¹⁵

Removal of Chlorides

The Initial concentration of chlorides recorded 215 mg/L.¹⁵ total dosages of *Moringaoleifera* and Tamarind seed powder ranges between 100 mg/L -350 mg/L used, among them 350 mg/L recorded most effective dose.¹⁵ 350 mg/L Coagulant dose of *Moringaoleifera* seed powder decreases the concentration of chlorides to 125 mg/L and the removal efficiency recorded 41.86%. 350 mg/L coagulant Mixture dose of both *Moringaoleifera* and

Tamarind seed powder decreases the concentration of chlorides to 107 mg/L where removal efficiency is 50.23%.¹⁵

Removal of Acidity

The Initial concentration of acidity was recorded 15mg/L.¹⁵ total dosages of *Moringaoleifera* and Tamarind seed powder used in the ranges between 100 mg/L -350 mg/L in which the dosage of 300 mg/L and 350 mg/L recorded most effective dose. 350 mg/L coagulant dose of *Moringaoleifera* seed powder decreases the concentration of acidity up to 3 mg/L whereas the Mixture coagulant dosage 300 mg/L and 350 mg/L of both *Moringaoleifera* and Tamarind seed powder decrease the concentration of acidity to 3 mg/L and the reduction efficiency recorded 80% for both *Moringaoleifera* and Tamarind seed powder.¹⁵

Total turbidity reduction by *Moringaoleifera* and the combination of both *moringaoleifera* and tamarind seed powder recorded 98.12%, and 98.75% by applying 250, and 250 mg/L dosages respectively.¹⁵ The acidity, alkalinity, pH, and chlorides were fixed in a treated sample of coagulants and maximum reduction efficiency was established in the combined use of *Moringaoleifera* and tamarind seed powder. The usage of nearby accessible natural coagulants was found to be appropriate, cost-effective, environment friendly, and sustainable for water purification.¹⁵

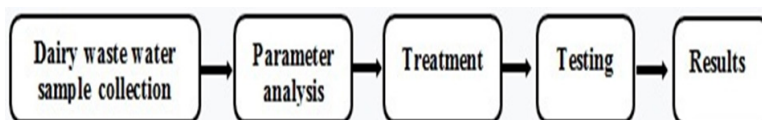


Fig. 4: Methodology of Experiment using Peanut/ Groundnut Shell Activated Carbon

Peanut/Groundnut Shell Activated Carbon Methodology and Discussion

Fig.4 shows the flowchart of methodology for Peanut Shell AC used by Wani and Patil¹⁶ for reducing the concentration of contaminants. TS concentration of dairy wastewater is decreased by up to 58% and the value of pH from dairy wastewater decreased by up to 12%. The Concentration of COD, BOD from dairy wastewater decreased by up to respectively 28% and 98%.¹⁶

Procedure to Prepare Peanut/Groundnut Shell Activated Carbon

Activated carbon prepared from groundnut shells by H_3PO_4 activation at average temperature was utilized.⁴³ Comprehensive discussion of has been elaborate and published earlier by Romero *et al.*,⁴² between the usage of the mass titration technique,⁴⁴ pH of the carbon at the place of 0 charges (pHpzc) was analyzed by depositing several quantities of carbon in 50 cm³ of a 0.1 M KNO_3 solution. The

stopper bottles were then allocated in a thermostat shaker for the whole night.⁴³

Procedure for Sample Analysis and Removal of pH, TS, BOD, and COD

The Dairy wastewater sample passed through a 6-inch pipe with a layer of peanut shell adsorbent was 60 cm. A 6-inch pipe was more effective than a 2.5 and 4-inch thick pipe and a 60 cm layer was more effective than a 20 and 40 cm of a layer.¹⁶ it occurred due to the large diameter and the height of the peanut shell adsorbent. The removal percentage of pH, TS, BOD, and COD from dairy wastewater is decreased by 12%, 58%, 98%, and 28% respectively. A pipe of 6 inches in diameter with an adsorbent

height of 60 cm is more efficient than the other pipes. When the pipe width and height of the substance were high, the performance of the adsorption of impurities from dairy wastewater would be highest.¹⁶ Use of peanut shell activated carbon in the water purification technique recorded good results.¹⁶

Pomegranate Peel Activated Carbon and Alum Flowchart for preparation of Pomegranate Peel AC

Al-Baidhani and Al-Khafaji prepared activated carbon made up of pomegranate peel.¹⁷ Fig.5 shows the procedure for making activated carbon from pomegranate peel which is given below.

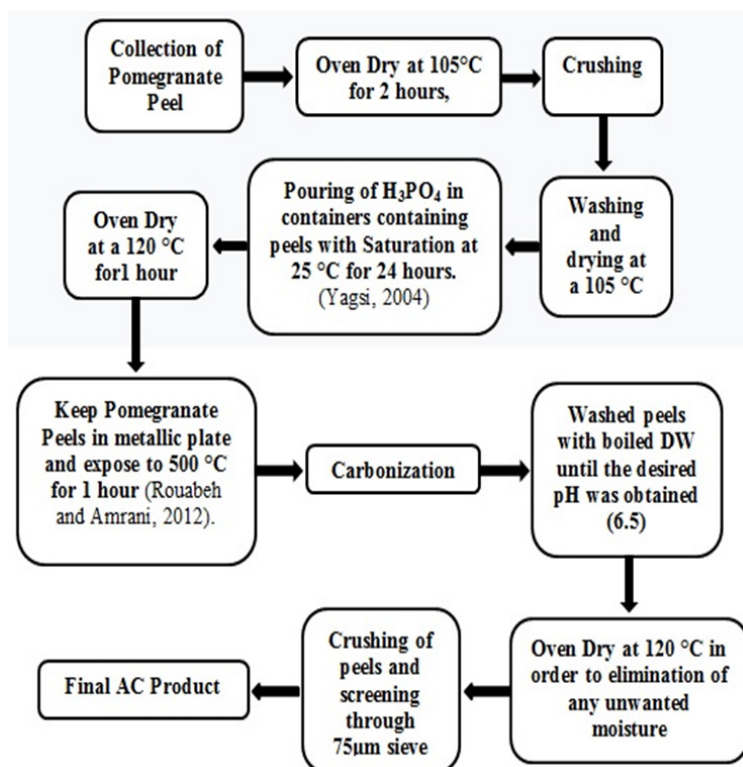


Fig. 5: Procedure for preparing Pomegranate Peel Activated Carbon

Removal of BOD, COD, Nitrates, pH, Phosphate Coagulation-flocculation-sedimentation (CFS) method utilized and this obtains a good ability to eliminate contaminants from effluent.¹⁷ highest removal efficiency of pomegranate peels a recorded 37.5% for BOD, 40.28% for COD, and 62.58% for Nitrate using pomegranate peel AC dosage of

20 g/L at pH 5 where recorded pH value of 6 is more efficient to remove nitrate. Maximum phosphate removal efficiency recorded 73% using a dose of pomegranate peel AC 15 g/L at a pH 5. The Removal efficiency of effluent contaminants enhanced when using local materials with alum as a coagulant. Recorded results using pomegranate peels and

alum Combined, removal capacity of BOD, COD, and Nitrate recorded 68.42%, 70.59%, and 78.0% respectively.

Rice Husk Ash

Previous Research of RHA

RHA (Rice Husk Ash) was described by Franklin 1979 for the water purification method in Thailand.³⁷ Mechanism is based on two-stage filtration, where the first layer is composed of fibers of coconut husks to filter the suspended solids from the contaminated water, and the second layer is composed with of a bed of incinerated rice husks to polish the remained turbidity and other pollutants. As discussed earlier Malhotra *et al.*,¹⁸ RHA are naturally present as a mesoporous medium of silica and carbon bond, which provides a wide area of involvement per unit mass. Though, RHA only adsorbs a limited quantity of bacteria.¹⁸ Das and Malhotra³⁸ defines a process to impart disinfected characteristics by integrating nanosilver particles in the RHA. Analysis reveals that once saturated with nanosilver, RHA can complete the inactivation of *E.coli*. Malhotra *et al.*,¹⁸ used a similar methodology to saturate RHA with the Fe(OH)₃ to keep it specific for the elimination of arsenic from contaminated water.

Preparation of RHA

RHA has been soaked for 10 minutes in 0.75 M FeCl₃ solution, during 3 M NaOH solution will be added with constant mixing until the pH ranges to 6.5. The Slurry is drained, and the cake is dried for 12 hours in an oven at 110°C. Coated RHA using Fe(OH)₃, analyzed for arsenic removal by making a column of 35gm substance and transferring groundwater injected with As³⁺ 250-300 ppb with the addition of As₂O₃.¹⁸

Removal of Arsenic

using Hydride Generator AAS (Atomic Absorption Spectrophotometer), samples of input and output water collected and analyzed for their arsenic content.¹⁸ Bed results indicate that while The initial 10-liter period, it eliminates arsenic present in the contaminated water and keeping the output from below 10 ppb as the WHO limit. The sustaining capacity is 10 liter for the arsenic output below 10 ppb as well as the arsenic output increases rapidly about 70 liters have carried after which the concentration of arsenic in the output water is equivalent to it in

the input water.¹⁸ while variations of arsenic content in the samples throughout 70 liters the bed's gross arsenic removal ability for input concentration of 250-300 ppb of As³⁺ recorded 0.25 mg/g.

Malhotra *et al.*,¹⁸ recorded that 8.3 kg column of RHA loaded with Fe(OH)₃ required 2000 liters of water for treatment. The volume for eliminating arsenic which exceeds international standards utilizing only by Fe(OH)₃. This treatment may not be desirable by itself but may be used as a complementary removal portion to another form of eliminating arsenic, such as coagulation and flocculation.¹⁸

Removal of Fluoride

Ganvir and Das³⁹ defined detailed procedures. Initially, 500 gm RHA soaked in 0.5 M AlSO₄ solution for 30 minutes in 2.5 liters distilled water. The Slurry is gently stirred for a further 30 minutes to ensure mixing and soaking of AlSO₄ into the RHA.¹⁸ 4 M solution of NaOH applied to the slurry gradually; maintain the stirring activity till the solution pH rises to 7. Added NaOH to the slurry leads to the formation of AlSO₄ precipitates at the ground and inside the RHA permeable medium. The Acquired slurry includes NaSO₄ and residual AlOH did not precipitate into the RHA. Then RHA is purified utilizing a vacuum filter, and dried for 12 hours at 110°C.^{39, 18} subsequent RHA filled with AlOH analyzed for fluoride elimination by generating column from 20gm content and spikes with 5 ppm of fluoride passing through groundwater. Water samples were taken at cycles of about 2 liters and tested for their fluoride material using a fluoride ion detector paired with a pH/ISE meter. Malhotra *et al.*,¹⁸ recorded bed display initially 6 liters cycle at which the bed can eliminated fluoride contents from spiked water.¹⁸

The Bed is no longer able to sustain the output fluoride intensity below 1.5 ppm after the initial 8 liters and the fluoride for output increases progressively until about 36 liters have crossed, wherein the concentration of fluoride in the output water is equivalent to that in the input water.¹⁸ while combining fluoride gap from input and output samples for the first 8 liters, Malhotra *et al.*,¹⁸ The recorded total fluoride removal ability of the bed which input concentration of 50 ppm ranges between 2,8 mg/g. According to recorded measurements, 5.23 kg of AlOH filled RHA required 2000 liters of water to

fulfill WHO drinking water regulations.¹⁸ efficiency of above RHA and AIOH bed can further be enhanced by bringing the pH of the input water slightly acidic where the adsorbing fluoride ions are more specific. The bed indicates a preliminary 8 liters cycle in which it can eliminate fluoride content recorded in the spiked water. For the next 8 liters, fluoride found in the water sample, but its concentration remains below to the WHO level 1.5 ppm.¹⁸ bed is not able to hold the output fluoride concentration under 1.5 ppm just after the initial 16 liters, so fluoride at output increases gradually while passing through 46 liters during the concentration of fluoride in the output water becomes equivalent to input water.¹⁸ Combining the difference for fluoride between input and output samples for the first 16 liters; Malhotra *et al.*,¹⁸ recorded the bed's removal efficiency to reach WHO standards, while approaching to 3.35 mg/g of AIOH, loaded RHA with groundwater carrying 5 ppm fluoride. A Minimum 3 kg of AIOH loaded RHA would be required to treat 2000 liters of water to fulfill the guidelines of the WHO.¹⁸

RHA Applications

Rice husk ash is a sustainable, renewable, low-cost water filtration biomass, due to its complex large surface area and mesoporous microstructure of silica.¹⁸ Inside a matrix, RHA may be engaged to produce capable medium trapping turbidity, saturation with disinfectants like nanosilver to impart anti-microbial properties, and impregnation with certain compounds like FeOH and AIOH to create a media capable of catching arsenic and fluoride in water. Given its enormous accessibility and insignificant costs, rice husk ash may decline developing countries crucial water contamination problems, mostly in India. Thus, this substance can help millions of people suffering from waterborne diseases like Cholera, typhoid, and diarrhea along with contamination attributable to water intake contaminated with toxic minerals such as fluorides and arsenic.¹⁸

Lemon and Banana Peel Powder

Preparation of Lemon and Banana Peel Powder

Dry the Lemon and banana peel to a brown color. Blend the lemon and banana peel to make it roughly size of 300 μm to fulfill the solubilization of active ingredients in the peel. Pour some Distilled water to the powder to make a 1% suspension.

The suspension eagerly oscillated for 45 minutes using a magnetic stirrer to boost water removal of the coagulant proteins, using filter paper. The filtrate section was utilized for an essential dose of coagulants.¹⁹

pH Effect

The pre-weighted 0.1 g of 300 μm coagulants collected by utilizing electronic balance and applied to each sample. The highest elimination takes place between 6-8 pH using both procedures for lemon and banana peels.¹⁹

Effects of Contact Time, Adsorbent Dosage and Particle Dimension

The total removal has occurred in both lemon and banana peel processes as pH ranges from 6-8.¹⁹ Calculated contact time set to 30, 60, 90, 120, and 150 minutes respectively at dosages 0.1 g of 300 μm of coagulant. The removal percentage rises suddenly when time increases.¹⁹ 0.1 g of 300 μm of coagulant at separate dosages of 0.05, 0.1, 0.15, 0.2, 0.25, 0.3g, and 0.35g respectively.¹⁹ The removal efficiency increased while increasing the density of the coagulant dosage. The maximum removal was achieved at 0.25 g of dose. 0.1 g of 300 μm of coagulant at separate particle dimensions 300, 425, and 600 μm respectively. The Decline in adsorbent particle dimension occur, rise in percent removal of BOD.¹⁹

Removal of Turbidity, Harness, BOD, pH, DO

The initial value of turbidity before the treatment was 38 mg/L and after treatment it was decreased to 5.2 mg/L.¹⁹ In the case of hardness, the initial value before treatment was recorded to be 684 mg/L and after treatment, it was decreased to 311 mg/L. The initial value of BOD before the treatment was 98 mg/L and after treatment, it was decreased to 11 mg/L. In the case of pH, the initial value before the treatment was observed 6.7 and after treatment, it turns into 7.6. The initial value of DO before the treatment was 5 mg/L and after treatment, it was increased to 12 mg/L.¹⁹ lemon and banana peel powder greatly increases the reduction efficiency of BOD and turbidity from conventional raw water. Using dosages of water-soluble banana and lemon peel solution decreased 89–96% of BOD and turbidity decreases from 38 to 5.2 NTU i.e. 95.89% after water treatment. It is observed that the lemon

peel is the most efficient element among the natural coagulant for removal of turbidity.¹⁹

Orange Peels Activated Carbon

Procedure for Making Orange Peels Activated Carbon

250 g of Orange peels have taken and cut into small pieces, clean with tap water and then dry it under the solar light for 24 hrs. the medium was ignited at various temperatures.⁸ material was placed in a metal vessel, and then, containers were put into a muffle furnace, carrying material individually at the pre-marked time and temperature; orange peels were burned at 200°C temperature for the interval of 1 hrs. As the bottom temperature in the carbonization exercise gives a fine result than high temperature,^{47, 8} following move out the samples from the furnace, the samples were settle down for the interval of 30 min at room temperature, cleaned with distilled water; to discard impurities and dust, and dried in the oven at 105°C for interval of 1 hrs. After that, the samples were squash into powder utilizing mortar and pestle and then screen using a sieve to discard big particles. For acid activation, 500 ml of three beakers were collected for the different three materials. The grinded orange peels were individually added to the 100 ml of concentrated phosphoric acid (H_3PO_4) in a 500 ml beaker, for the interval of 24 hrs. This will assist in the rising porosity of activated carbon simultaneously rises the surface area for adsorption exercise.^{48, 8} the immersed shells and peels were burnt at a similar time and temperature which was taken primarily before the carbonization exercise.

Then, the samples were again immersed in 100 ml of distilled water with 1 gm of sodium-bicarbonate for an interval of 24 hrs; surplus phosphoric acid was discarded from the sample. Samples were then cleaned individually with distilled water for 4–5 times up to neutralization of pH. The cleaned samples were dry at 110 OC. The activated carbon of the medium was a grind and screened to a 75 μm , 150 μm and 425 μm mesh size to get a various sized activated carbon. Dry and screened samples were kept in the dry and clean container.⁸

Removal of COD and TSS

COD and TSS removal by 75 μm at 500 mg/l concentration was noticed to be 99.29% and 100%, respectively, removal of COD at 200 mg/l was to 97.41% noticed and removal of TSS was to be 100%.⁸ At 100 mg/l, 91.27% COD and 92.85% of TSS removal were noticed. By 150 μm size and at 500 mg/l, 92.22.5% COD removal and 100% TSS removal was noticed. COD removal by 150 μm at 200 mg/l concentration was to be 91% and TSS removal was 85.71%. at the duration of 100 mg/l concentration by 150 μm COD removal was to be 89.86% and at the duration of 100 mg/l concentration by 150 μm TSS removal decreased drastically, which is 78.57%.⁸ COD and TSS removal by 425 μm size activated carbon at 500 mg/l concentration was 86.55% and 64.28%, respectively. The same size activated carbon at 200 mg/l orange peels performed better due to the formation of more C–O and C=O functional groups.^{49, 8}

Table 3: Several Adsorbent, Pollutants, and Reduction efficiency from the reported Water sample.

Sr. No.	Adsorbent	Pollutants	Reduction efficiency of adsorbent dosages	Reference
1	Coconut Shell	Turbidity Hardness	200 g for 30 mL/s water flow rate At dose 0.06 to 0.3 g/cm ³ , the reduction efficiency increases to 0.24 g/cm	14, 32
2	Moringaoleifera and Tamarind seed powder	Turbidity pH Acidity Alkalinity Chlorides	At dose 250 mg/L turbidity decreases 4 NTU where recorded reduction efficiency 98.75%. At dose 300 mg/L and 350 mg/L pH ranges to 7.1 where recorded reduction efficiency 19.31% At dose 300 mg/L and 350 mg/L acidity decrease the to 3 mg/L where reduction efficiency recorded 80% At dose 350 mg/L alkalinity decreases to 80.15 mg/L where reduction efficiency Recorded 67.35%. At dose 350 mg/L chlorides decreases to 107 mg/L	15

3	Peanut Shell	pH	where reduction efficiency recorded 50.23%. concentration of pH recorded 12%	16
		BOD	reduction efficiency of BOD recorded 98%	
		COD	Reduction efficiency of COD recorded 28%	
		TS	reduction efficiency of total Solids recorded 58%	
4	Pomegranate Peel	BOD	At dose 20 g/L efficiency Recorded 37.5%	17
		COD	At dose 20 g/L efficiency Recorded 40.28%	
		Activated carbon	Nitrate At dose 20 g/L efficiency Recorded 62.58%	
		Phosphate	At dose 15 g/L efficiency Recorded 73%.	
5	Rice Husk Ash	Arsenic	Removal efficiency for input 250-300 ppb of As ₃₊ recorded 0.25 mg/g.	18
		Fluoride	Removal efficiency for input concentration of 50 ppm ranges between 2, 8 mg/g.	
6	Lemon and Banana Peel	Turbidity,	Initial value prior treatment recorded 38 mg/L and after treatment it decreases to 5.2 mg/L.	19
		BOD,	Initial value prior treatment recorded 98 mg/L and after treatment it decreases to 11 mg/L.	
		Hardness,	Initial value prior treatment recorded to be 684 mg/L and after treatment it decreases to 311 mg/L.	
		DO	Initial value prior treatment recorded 5 mg/L and after treatment it increases to 12 mg/L.	
		pH	Initial value prior treatment recorded to be 6.7 and after treatment it recorded 7.6.	
7	Orange peels	COD	at duration of 100 mg/l concentration by 150 µm COD removal was to be 89.86%	8
		TSS	at duration of 100 mg/l concentration by 150 µm TSS removal decreased drastically, which is 78.57%	

Conclusion

The water treatment techniques employed by the various researchers were discussed in this review article. (Table 3) Shows brief results of adsorbent, pollutants, and Reduction efficiency of adsorbent dosages. The activated carbon and ash produced from waste and raw material such as Coconut shell, Moringaoleifera seed, Peanut shell, Pomegranate Peel, Rice Husk Ash, Lemon-Banana peel and Orange peels are the tremendously useful component for treating the contaminated water. It was proven that these waste products can remove various physical, chemical, biological, and heavy metals contaminants such as Turbidity, Hardness, Conductivity, Total Coliform, pH, Acidity, Alkalinity, Chlorides, Cu, Ni, Zn, BOD, COD, TSS, Nitrate, Phosphate, TDS, Color, Turbidity, Fluoride, and DO from contaminated water. This household raw material is easily available everywhere. The usage of this raw material for water purification was found to be innovative, satisfactory, cost-effective, environmentally friendly, and renewable. This

reviewed study demonstrates adaptability for using these secure and worldwide accepted techniques.

Acknowledgement

I am very thankful to my Research Guide Prof. Dr. Satish S. Patil for his Precious support. Also I am thankful to my Research colleagues and Department of Environmental Science, Dr. BAM University, Aurangabad (MS), India. I am also Grateful to the reviewers and editor of the journal for their Helpful Instructions over the span of course while manuscript preparation.

Funding

The author and Co Author got no any budgetary help for the authorship, creation, publication and research study of this review article.

Conflict of Interest

The authors don't have any conflict of interest.

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