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GRAVITY WATER PURIFIER USING ACTIVATED CARBON FROM COCONUT SHELL FOR RURAL APPLICATION

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Abstract

In present study experimental approach has been used to analyze the performance of energy efficient water purifier system. The purifier consists of five stage separator, which includes micron filter, granular filter and activated charcoal. Setup is fabricated with flow rate ranging of 0.6 ml/sec- 1 ml/sec. Activated carbon prepared from coconut shell. FESEM micrograph revels the presence of micro-nano sacle porosity on the surface of activated carbon. Zeta sizer shows 25±5 nm size of carbon granuels. Activated carbon in gravity purifier provides a cost effective method for water purification. The micro-nano porosity is more effective for removal of suspended impurity.
Key words : Micron filter, Activated charcoal, Graphene membrane, Water purifier.

Introduction

Access of drinking water purification technology at low cost is essential for due to rapid growth in population and increasing scarcity of water. Water purification technology allows reuse of wastewater, hence relieve the pressure on fresh water resources (Tong *et al.*, 2016). Chemical (Chlorine, Bromide, iodine, ion exchange), filteration (reverse osmosis, charcoal) and oxidation (aeration, ozone) are main methods used for water purification. Among these existing methods the sepration is most widely used due to its high stability, low operating cost, and ease operation (Ma *et al.*, 2017). Table 1 listed some of the filteration methods used for water purification. It can be observed that charcoal fiter proves an cost effective method for water purification.

Table 1: Method for water purification

Method	Remark
Chlorine	It is most widely used, but extremely toxic and can causes heart diseases
Slow Sand	In this 1 cubic meter water can passes at rate 2 liters/min, and does a limited bacteria removal
Pressure Sand	In this, 1 cubic meter water can passes at the rate of 40 gram per minute and must be backwashed daily.
Porous Stone or Ceramic	Filters are small but expensive, and do not effect chemicals, bacteria or odors
Paper or Cloth	Filters are disposable and filter to one micron, but do not have much capacity.
Charcoal	It can remove chemicals and lead, but is easily clogged, so should be used with a sediment prefilter
Granular Charcoal is cheaper, but water can flow around the granules without being treated. Powdered Charcoal is a very fine dust useful for spot cleaning larger bodies of water, but is messy and can pass through some filters and be consumed.	
Reverse Osmosis	It uses a membrane with microscopic holes that require 4 to 8 times the volume of water processed to wash it in order to remove minerals and salt, but not necessarily chemicals and bacteria.
Enzymes & Bacteria	Combined can remove contaminants, reduce sludge, and even digest oil. See recent article on enzymes & bacteria.

Water based work are widely focus of research community (Garg *et al.*, 2018; Kumar *et al.*, 2016; Bhatt, 2012; Soogi *et al.*, 2010; Chahartaghi *et al.*, 2019).The advent of nanpoparticles in improving the performance is considered as new breakthrough (Mishra *et al.*, 2017; Mishra *et al.*, 2018; Ghosh *et al.*, 2019; Kumar *et al.*, 2011; Paul *et al.*, 2012; Paul *et al.*, 2014; Paul *et al.*, 2015; Ahmadi *et al.*, 2019b). Authors have used nanoparticels in nanolubricants (Kotia *et al.*, 2018; Kotia and Ghosh 2017; Chowdary *et al.*, 2019) and heat transfer (Khurana *et al.*, 2017; Raj *et al.*, 2016; Dondapati *et al.*, 2017; Bhat *et al.*, 2017; Jaffri *et al.*, 2017; Agnihotri and Sharma, 2015; Chahartaghi *et al.*, 2019; Ghazvini *et al.*, 2020, Ahmadi *et al.*, 2019a;). Carbon based material provide a cost effective method for water purification.

Carbon based nanomaterial includes activated carbon, MWCNTs (Mehra *et al.*, 2014; Kesharwani *et al.*, 2015; Mishra *et al.*, 2018, Naidu *et al.*, 2014; Anjana *et al.*, 2016; Chawla *et al.*, 2017; Rong *et al.*, 2018; Parashar *et al.*, 2019), graphene (Kaur and Kumari, 2014), graphene oxide and carbon dots. The activated carbon (Singh and Rattan, 2014; Vardharajula *et al.*, 2012; Singh *et al.*, 2017; Singh *et al.*, 2017; Mudila *et al.*, 2019) are among cheaply available carbon material for water purification. The present study focused on the use of coconut shell to produce activated carbon and tested for water purification.

Materials and Methods

Samples prepared with raw coconut shell. Figure 1 show the process chart for preparation of activated carbon. The shell is processed furanace under limited supply of air to remove volatile material. Then the carbon is get grinded and filter to produce an uniform size.

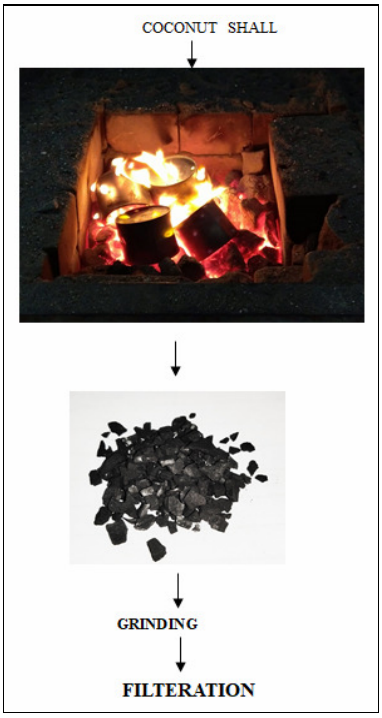


Fig. 1 : Preparation of activated carbon

Garvity purifier structre:

The purifier is made up in six section, which provide an verticle 1.5m head of water. This pressure head is utilize for flow of water in different sections. In initial section (1) water is passes through an micron filter. This will separate our dispersed micron size impurity. A ceramic component, korea ceramic (commercial name) is used as filter in this section, as shown in Figure 2. Its pores can be clean by any fine brush.

Fig. 2 : Ceramic filter

In second section, water passed through gravel bed (arrange in fine to coarse), this make flow stagnate. The bed is embedded with alum to remove harness in water. The cartiledge column filter is arranged in third section, which is made of elliptical structure of clay. This clay structure is to maintain low temperature and elliptical shape support to built up positive pressure.

Fourth section is presseriser to make flow from activated carbon bed. It is an clay structured with oval shaped structure. Fifth section is stagnation camber to give time for settle down for dispersed particles. The end section (sixth) is make to take out pure water for testing & usages. Figure 3 shows the detailed of water purifier.

1	Micron filter (fordispersed impurities of 0.5 um)
2	Cartiledge
3	Pressureizer (Acrivated Carbon)
4	Stagnation Chamber
5	Dispenser

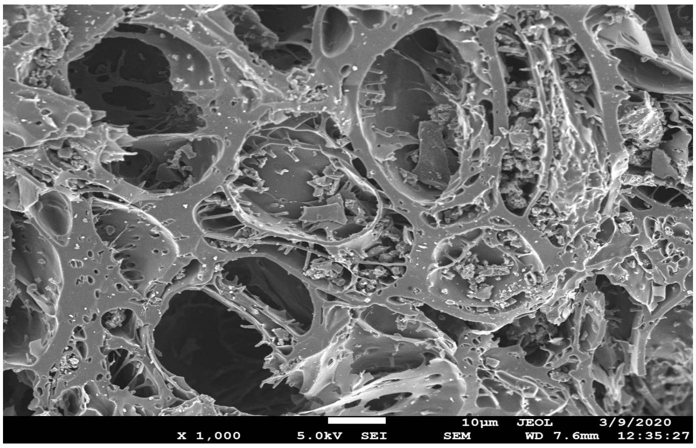
Fig. 3: Structure of purifier

The calibration of TDS meter and electric resistivity equipment is done by analyzing standard sterelite water. Figure 4 shows the image of standard sterelite water used in present study. The sample shows TDS as 8 (20.4 ^{o}C) and 9 (20.1±0.1^{o}C) in four consequtive reading. The resistivity was 1±0.1 ohm.

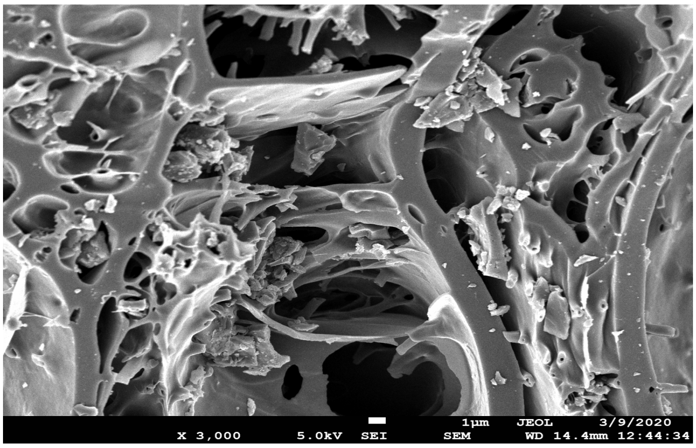
Fig. 4: Standard distill water

Results and Discussion

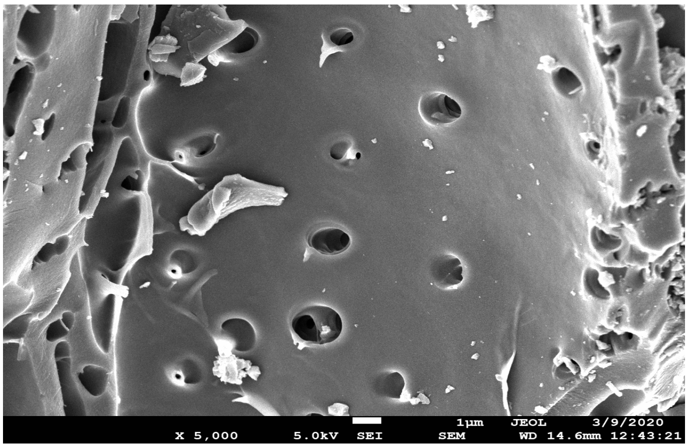
Further characterization on the morphology and size is performed using FESEM and zeta potential. Figure 5(a-c) shows FESEM images of coconut shell based activated carbon.



(a)



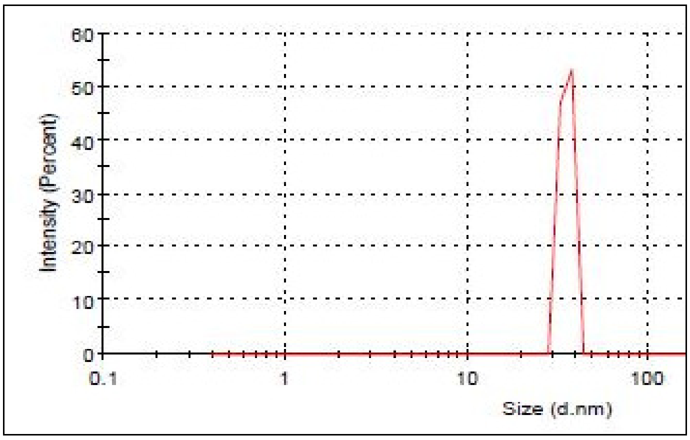
(b)



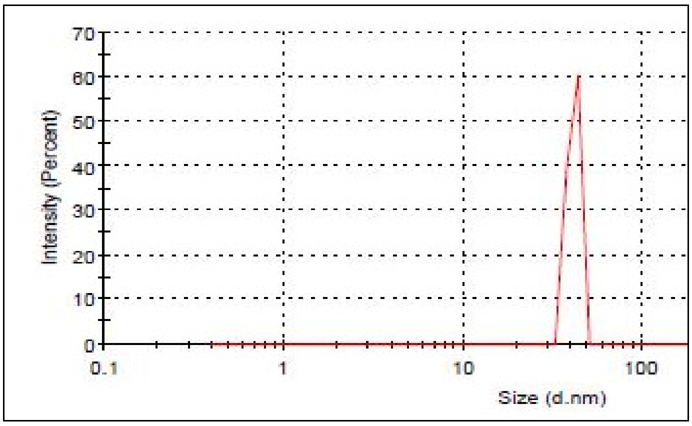
(c)

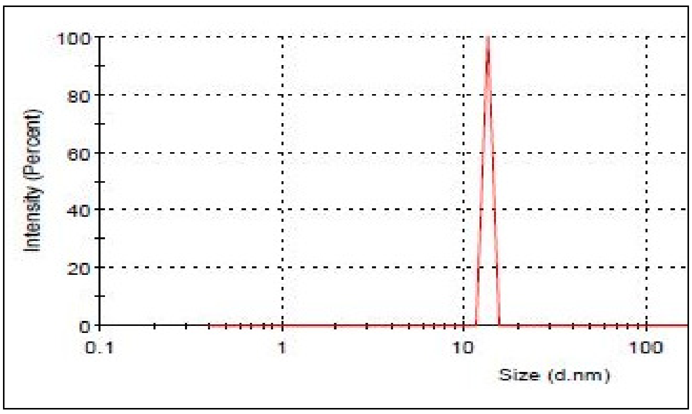
Figs 5 (a-c) : FESEM

The size of activated carobn is measured by nano zeta zetasizer. Figure 6 (a-c) shows the repetive reading of zeta sizer. It can be observed that size of activated carbon was 25±5 nm.



(a)





Figs. 6 (a-c): Zeta Sizer

Figure 7 shows the zeta potential of activated carbon sample. It shows -14.2 mV, -15.8 mV and -13.7 mV in three consequtive readings. The negative zeta potential shows the net change of scattering object is negative.

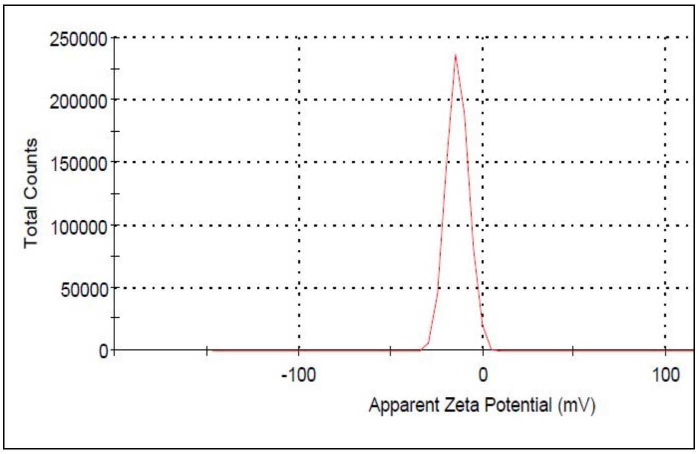


Fig. 7: Zeta Potential

Initial testing of gravity purifier is performed without activated carbon. The sample produce data listed in Table 2. It can be observed that initial TDS is 322 with 0.72 ml/s flow rate, how ever it increases to 640 with increase in flow rate 0.95 ml/s.

Table 2: TDS and resistivity wihout activated carbon

Sample 1; Flow rate 0.72 ml/s	
TDS (Temperature)	**Resistivity**
322 (21.2 °C)	1.9
320 (21.4 °C)	1.97
325 (21.1 °C)	1.96
Sample 2; Flow rate 0.95 ml/s	
TDS (Temperature)	**Resistivity**
638 (18.1 °C)	1.3
640 (17.9 °C)	
641 (17.9 °C)	

Table 3 shows the TDS and resistivity of water with activated carbon. It can be observed that TDS is significantly improves with carbon filter. As the temperature decreases to 3 °C, there is more magnitude of TDS for activated carbon. However there was no significant improvement in quality of water observed as initial sample already was in satisfactory good quality and have lesser suspended imprurities. The micro-nano porosity of activated carbon mainly useful in removing suspended impurities.

Table 3: TDS and resistivity activated carbon

Sample 1; Flow rate 0.71 ml/s	
TDS (Temperature)	**Resistivity**
361 (17.2 °C)	1.4
358 (17.4 °C)	
359 (17.4 °C)	

Sample 2; Flow rate 0.68 ml/s	
TDS (Temperature)	**Resistivity**
346 (17.0 ^oC)	1.4
347 (17.1 ^oC)	
346 (17.1 ^oC)	
Sample 3; Flow rate 0.66 ml/s	
TDS (Temperature)	**Resistivity**
341 (16.8 ^oC)	1.4
341 (16.9 ^oC)	
338 (16.9 ^oC)	

Conclusion

In present paper water purification capacity of activated carbon is performed in a gravity purifier. Activated carbon is prepared form coconut shell in a furface under limited supply of oxygen. FESEmand zeta sizer images revel the presence of micro-nano holes on the surface of carbon and size of carbon as25±5 nm. Activated carbon provides improved water purification and the presence of micro-nano indicates its suitability for removal of suspended impurity.

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