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Performance of modified bio-filter on physico-chemical properties of water samples of Naini, Allahabad

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Abstract
The experiment was conducted to know the working performance of modified biofilter for different physico-chemical properties of water samples from different sources at Naini, Allahabad. The percent variation in deferent parameter after purification was found significant, the parameters viz pH, EC, temperature, Calcium Hardness, Turbidity, TDS and Chloride after purification by biofilter were found under the permissible limit as per BIS standard. The total hardness, magnesium hardness after purification were found beyond the permissible limit in all water samples and Arsenic were also recorded beyond the permissible limit in water samples contaminated as 10 ppm and 20 ppm Arsenic Artificially. The performance of Biofilter was highly effective in removal efficiency and balancing of different water parameter. Percent variation in all parameter ranges from minimum 0.70 - 0.84% and maximum 80% - 91%.

Keywords: Water treatment, biofilter, Physico- chemical parameter, rich husk, and column Arsenic removal efficiency

1. Introduction
Environment is the total surroundings including both biotic and abiotic components, both the communities and their physical surrounding exert a profound influence on one another which in turned shape the overall characteristics of the environment Mathanam (1974) [9]. Water is very important to life, without water our life cannot move. Safe drinking water is the primary need of every human and also their basic fundamental right. It is well known that clean water is absolutely essential for several purposes for healthy living Mandalam *et al*. (2009) [8]**.** Environmental pollution is one of the most serious problems we are facing today. Metal pollution is one of the major causes of environment pollution. Arsenic exposure to human is mostly through drinking water. Toxicity of Arsenic totally depends on the form in which arsenic is present. Inorganic arsenic, typical in drinking water, is much more toxic than organic ones. Arsenic may attack internal organs without causing any visible print, so it's very difficult to recognize. The indispensability, deficiency or toxicity of arsenic is manifestation of dose response effects; blood is also a good indicator for presence of arsenic in human body Neha *et al.* (2013) [11]. The presence of hazardous concentrations of arsenic in drinking-water and the serious health effects this situation is causing to untold hundreds of millions of people across the planet, have led the World Health Organization (WHO) to recommend that the maximum concentration of arsenic in human drinking water not exceed 10 µg/L Maria (2006) [10].
Biofilter is one of the available alternative forms of bio-filter technology used for filtration of drinking water which is easily available in rural areas since it is cheap, simple to assemble and maintained apart from being eco-friendly. The use of rice husk as a bio-adsorbents for removal of heavy metals form surface and drinking water has been found to be cost effective.
Heavy metals are kept under environmental pollutant category due to their toxic effects in plants, human and food. Some of the heavy metals Arsenic (As), Cadmium (Cd), Lead (Pb), Mercury (Hg) are cumulative poison. These heavy metals are persistence, accumulative and are not metabolized in other intermediate compounds and do not easily breakdown in the environment Ghaedi *et al.* (2013) [4]**.** Drinking arsenic-contaminated water leads to a series of health problems. Arsenic is a toxic metalloid element that is now recognized to be an important contaminant in drinking water in many countries of south-East Asia including Bangladesh Sohel *et al.* (2009) [13].

Materials and Method

The experiment on "Performance of Modified Bio-filter on Physico-chemical Properties of Water Samples" was performed in the Laboratory of Department of Environmental Science, School of Forestry and Environment, Sam Higginbottom Institute of Agriculture, Technology and Science (S.H.I.A.T.S) (Deemed to be University), Allahabad, U.P, and India.

Materials required for bio-filter and fixed bed column adsorption:

Pitcher (clay vessel), Pipe, Charcoal, Different sizes (small, medium, large) of gravels, Fine sand, Coarse sand, hollow cylindrical tube pipe, Sieve, Iron stand, Rice husk 1.18mm.

Treatments of rice husk before use in experiment:

Untreated rice husk: used only for distilled water, **Physical treatment of rice husk:** The rice husk was washed with distilled water to remove dust and other foreign particles. The cleaned biomass was dried in sunlight for 48-72 hrs.

Mechanical Treatment: The aim of mechanical treatment of rice husk not only size reduction and increasing digestibility of cellulose and hemicelluloses, but also it can increase specific surface area for solute surface interaction. This is due to the fact that, larger surface area was increase adsorption capacity at equilibrium. The mechanical treatment would include chopping; hammer milling; grind milling; roll milling; vibratory milling and ball milling. These are considered as successful and low cost treatment strategies (De Sousa *et al.* (2004). The materials was grained and sieved to mesh sizes 1.18 mm. The medium material was stored for further use.

Chemical treatment of rice husk: Chemical treatments of rice husk are able to reduce the content of hemicelluloses, lignin and cellulose crystalline. The reduction in crystalline leads to an increase the specific surface area for treated rice husk compared to untreated rice husk (Daffalla *et al.* 2010).

Acid treated rice husk: The modification is carried out by stirring then immersing NRH in (0.1 M) hydrochloric acid (HCl) till saturation for 1 hour at room temperature. The treated rice husk is washed with distilled water and dried in sunlight for 48-72 hrs. The final product is labeled as Acid treated Rice Husk (ARH).

Assembling of fixed bed column and Biofilter: - The cylindrical column 10cm diameter with a suitable outlet was used. The bed heights 3 feet, diameter of the column and flow rate were kept constant (20ml/min) at rice husk was used 45cm height as the filtration bed in the column in which a sieve was used to hold the bed of rice husk. The column was hold using a stand and the Pitcher with a tiny pore was kept at the top of the biofilter vessel. The vessel with a suitable outlet was used as the base of the biofilter, the inside of the vessel was layered with different layers of sand, charcoal and gravels.

Work plan: - The experimental setup of modified bio-filter was assembled in the laboratory of the department. The setup contains two section of the setup one is bio-filter to reduces the impurity from the drinking water and another section contains the column to reduces the concentration of Arsenic (As) from the drinking water. The column was connected to the biofilter with a pipe trough the above clay pot (Pitcher) on the top of the biofilter setup. The drinking water was poured through the column to remove of Arsenic from drinking water and after filtration it was passed on to the biofilter for further removal of pollutants. The bed height of (45cm) Rice husk used (750g rice husk) diameter column (10cm) and flow rate was (20 ml/min) respectively.

The hundreds millions of people daily used drinking water with arsenic concentration several time higher than the world health organization (WHO) recommended limit of 10 millionth of a gram per liter of water (10 µg/L) therefore, water samples with different amount of arsenic was filtered in column and it was passed to the bio filtration for removal of other pollutants.

The untreated water samples was first analyzed for the following parameters viz pH by Digital pH meter (Jackson,1958), EC $_{\text{at } 25^{\circ}C}$ mmho/cm by Digital Conductivity meter (Jackson,1958), Total hardness, Ca and Mg by EDTA titration (Trivedy and Goel,1984), TDS by Digital TDS meter (Geneva,1984), Turbidity by Digital Turbidity meter (APHA,1976), chloride by Argentometric method (Moser,1976) and Arsenic by Atomic absorption spectrophotometer (Elico, Haring *et al.* 1982), after filtration through the modified biofilter the treated water samples was again analyzed for the same parameters with standard procedures (American Public Health Association, 1999) "Standard Methods for Examination of Water and Wastewater, 20th edition".

Arsenic Removal efficiency of metal ions was calculated using the following

$$\text{Removal Efficiency (\%)} = \frac{\text{Co} - \text{CX100}}{\text{Co}}$$

Whereas, Co and C are the concentrations of Arsenic in sample water before and after the treatment, respectively.

Experimental study results Effect of column diameter and bed height As shown in different removal efficiencies were achieved at 10cm diameter columns for the fixed adsorbent quantity of rice husk (750g) and influent metal concentration by keeping the flow rate constant (20mL/min). The whole experiment was repeated for the influent metal concentrations of 10 ppb and 20 ppb.

BIS standards for drinking water

S. No.	Parameter	Bis Standard	
		Desirable Limit	Permissible Limit
1	pH	6.5	8.5
2	EC	0mmhos/cm	2mmhos/cm
3	Total Hardness	300 mg/l	600 mg/l
4	Calcium Hardness	75 mg/l	200 mg/l
5	Magnesium Hardness	30mg/l	100mg/l
6	TDS	500 ppm	2000 ppm
7	Turbidity	5 NTU	10 NTU
8	Chloride	250mg/l	1000mg/l
9	Arsenic	0ppm	0.05ppm

Result and Discussion

pH: Among the four sample the minimum pH (7.03) before filter, was found in a water sample collected from Tap Water of SHIATS whereas, the maximum pH (7.12) was measured in water sample contaminated with 20 ppm arsenic. After purification by biofilter the minimum pH (6.99) was found in water sample collected from tap of SHIATS and maximum pH (7.07) was recorded in water sample contaminated with 20

ppm arsenic artificially. pH was within the desirable and permissible range of drinking water quality standards by BIS. Similar finding was recorded by Kehoe *et al*. (2001) [7]

EC: Among the four samples the minimum EC (0.95 mmhos/cm) before filter, was found in a hand pump water sample collected from Arail village and whereas, the maximum EC (1.22 mmhos/cm) was measured in water sample contaminated with 20 ppm arsenic. After purification by biofilter the minimum EC (0.87 mmhos/cm), was found in a water sample collected from Arail village and maximum EC (0.98 mmhos/cm) was recorded in water sample contaminated with 20 ppm arsenic artificially, Electrical conductivity was within the desirable and permissible range of drinking water quality standards by BIS. Similar finding was observed by Amir (2007) [2]

Total hardness: Among the four sample the minimum Total hardness (1300mg/l) before biofilter was found in water sample collected from Tap water SHIATS and whereas the maximum Total hardness (1400mg/l) before biofilter was measured in water sample contaminated with 20 ppm arsenic. After purification by biofilter the minimum Total hardness (1200mg/l) was found in water sample collected from Tap water SHIATS and maximum Total hardness (1300mg/l) was recorded in water sample contaminated with 20 ppm arsenic artificially, in water hardness is mainly contributed by bicarbonates, carbonates, sulphates and chloride of calcium and magnesium. Total hardness was beyond the desirable and permissible range of drinking water quality standards by BIS. Similar finding was observed by Peter *et al.* (2003) [12]

Ca hardness: Among the four sample site the minimum Calcium hardness (100 mg/l) before biofilter, was found in water sample collected from tap water of SHIATS and whereas the maximum Calcium hardness (150 mg/l) before filter was recorded in water sample contaminated with 20 ppm arsenic. After purification by biofilter the minimum Calcium hardness (90 mg/l), was found in a water sample collected from tap water of SHIATS and maximum Calcium hardness (127 mg/l) was recorded in water sample contaminated with 20 ppm arsenic artificially. Calcium hardness was within the desirable and permissible range of drinking water quality standards set by BIS. Similar finding was observed by Peter *et al*. (2003) [12]

Mg hardness: Among the four samples site the minimum Mg hardness (1200mg/l) before biofilter was found in a water sample collected from tap water of SHIATS and whereas the maximum Mg hardness (1250mg/l) before filter was measured in water sample contaminated with 20 ppm arsenic. After purification by biofilter the minimum Mg hardness (1110mg/l) was found in a water sample collected from tap water of SHIATS and maximum Mg hardness (1165mg/l) was recorded in water sample contaminated with 20 ppm arsenic artificially. Magnesium hardness was within the not desirable and not permissible range of drinking water quality standards set by BIS. Similar finding was observed by Peter *et al.* (2003) [12]

TDS: Among the four samples site the minimum Total Dissolved Solids (365 ppm) before biofilter, was found in a water sample collected from Tap water SHIATS and 20 ppm Arsenic concentration contamination water, and whereas the maximum Total Dissolved Solids (458ppm) before filter was measured in water sample contaminated with Tap water SHIATS and 20 ppm arsenic. After purification by biofilter the minimum Total Dissolved Solids (300 ppm), was found in a water sample collected from Tap water SHIATS, and maximum Total Dissolved Solids (395 ppm) was recorded in water sample contaminated with 20 ppm arsenic artificially. Total dissolved solid was within the desirable and permissible range of drinking water quality standards set by BIS. Similar finding was observed by. Graf *et al.* (2010) [5]

Turbidity: Among the four samples site the minimum Turbidity (8 NTU) before biofilter was found in a water sample collected from Tap water SHIATS, and whereas the maximum Turbidity (57 NTU) before filter was recorded in water sample contaminated with Arail Hand pump water. After purification by biofilter the minimum Turbidity (3 NTU) was found in a water sample collected from Tap water SHIATS, and maximum of Turbidity (12 NTU) was measured in water sample contaminated with Arail Hand pump water, the causes of turbidity are primarily natural with some contribution from anthropogenic source Ince, M. *et al*. (2010) [6].

Chloride: Among the four samples site the minimum Chloride (155mg/l) before biofilter, and whereas the maximum Chloride (105mg/l) before filter, was measured in water sample contaminated with Arail Hand pump water. After purification by biofilter the minimum Chloride (50mg/l), was found in water sample collected from Tap water SHIATS, and maximum of Chloride (65mg/l), was recorded in water sample contaminated with 20 ppm arsenic artificially. Chloride in all samples within the permissible limit value. Chloride was within the desirable and permissible range of drinking water quality standards set by BIS. Similar finding was observed by Awrajaw *et al.* (2014) [3]

Arsenic: Among the four samples site the minimum Arsenic (0.05µg/L) before biofilter, and whereas the maximum Arsenic (20 µg/L) before filter, was measured in water sample contaminated with 20 ppm Arsenic concentration contamination water. After purification by biofilter the minimum Arsenic (0.01 µg/L), was found in a water sample collected from Tap water SHIATS, and maximum of Arsenic (2.10 µg/L), was recorded in water sample contaminated with 20 ppm arsenic artificially, Arsenic in all samples within in the permissible limit value. Similar values come in Arsenic was within the desirable and permissible range of drinking water quality standards set by BIS (0.05) and WHO (0.01). Similar finding was observed by Abdul Khayum (2011) [1].

Table 1: Physical and Chemical characteristics of drinking water samples at Tap water of SHIATS

Parameters	Before Filter				After Filter			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
pH	7.07	7.03	7.05	7.05	7.00	6.99	7.01	7.00
EC	1.08	1.06	0.10	1.08	0.95	0.93	0.94	0.94
Total hardness	1300	1200	1400	1300	1200	1100	1300	1200
Ca hardness	100	90	110	100	90	85	95	90
Mg hardness	1200	1150	1250	1200	1110	1100	1120	1110
TDS	365	355	375	365	300	290	310	300
Turbidity	8	7	9	8	3	2	4	3
Chloride	105	100	110	105	50	40	60	50
Arsenic	0.05	0.04	0.06	0.05	0.01	0.01	0.01	0.01

Table 2: Physical and Chemical characteristics of drinking water samples at Hand pump Water of Arail

Parameters	Before Filter				After Filter			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
pH	7.11	7.10	7.12	7.08	7.06	7.05	7.07	7.03
EC	0.95	0.94	0.96	0.95	0.87	0.86	0.88	0.87
Total hardness	1350	1300	1400	1350	1250	1200	1300	1250
Ca hardness	125	115	135	125	110	105	115	110
Mg hardness	1225	1200	1250	1225	1140	1130	1150	1140
TDS	390	385	395	390	320	310	330	320
Turbidity	57	56	58	57	12	11	13	12
Chloride	120	110	130	120	55	45	65	55
Arsenic	3.10	3.09	3.11	3.10	0.50	0.40	0.60	0.50

Table 3: Physical and Chemical characteristics of drinking water samples at Artificially 10 ppm Arsenic contaminated water

Parameters	Before Filter				After Filter			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
pH	7.10	7.09	7.11	7.10	7.04	7.03	7.05	7.04
EC	1.03	1.02	1.04	1.03	0.95	0.94	0.96	0.95
Total hardness	1300	1200	1400	1300	1200	1100	1300	1200
Ca hardness	140	130	150	140	120	115	125	120
Mg hardness	1210	1205	1215	1210	1130	1120	1140	1130
TDS	412	410	414	412	350	340	360	350
Turbidity	9	8	10	9	4	3	5	4
Chloride	130	120	140	130	60	50	70	60
Arsenic	10	9	11	10	0.90	0.80	1.00	0.90

Table 4: Physical and Chemical characteristics of drinking water samples at Artificially 20 ppm Arsenic contaminated water

Parameters	Before Filter				After Filter			
	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
pH	7.12	7.11	7.13	7.12	7.07	7.06	7.08	7.07
EC	1.22	1.21	1.23	1.22	0.98	0.97	0.99	0.98
Total hardness	1400	1350	1450	1400	1300	1250	1350	1300
Ca hardness	150	140	160	150	127	126	128	127
Mg hardness	1250	1200	1300	1250	1165	1155	1175	1165
TDS	458	454	462	458	395	385	405	395
Turbidity	10	9	11	10	5	4	6	5
Chloride	155	145	165	155	65	55	75	65
Arsenic	20	15	25	20	2.10	2.05	2.15	2.10

Conclusion

The results of experiment are concluded as the assembling and working efficiency of modified biofilter for different parameter. The percent variation in deferent parameter after purification was found significant, the parameters viz pH, EC, temperature, Calcium Hardness, Turbidity, TDS and Chloride after purified by modified Biofilter were found under the permissible limit as per BIS standard. The total hardness, magnesium hardness after purification were found beyond the permissible limit in all water samples and Arsenic were also recorded beyond the permissible limit in water samples contaminated with 10 ppm and 20 ppm Arsenic Artificially. The performance of Biofilter was highly effective in removal efficiency and balancing of different water parameter. Percent variation in all parameter ranges from minimum 0.70 - 0.84% and maximum 80% - 91%.

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