

ARSENIC (III) REMOVAL FROM DRINKING WATER USING RUST WASTE SAND FILTER

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EXTENDED ABSTRACT

L'acqua potabile è un diritto universalmente riconosciuto: l'OMS e l'UNICEF hanno rilevato attraverso accurati monitoraggi, che attualmente in Bangladesh circa quattro milioni di persone non hanno accesso all'acqua potabile, e la maggior parte dei dati si riferisce alla capitale Dhaka City (ALI, 2019). Di notevole e fondamentale interesse è la presenza in acqua di metalli pesanti, in particolare dell'arsenico, considerato un importante inquinante ambientale con effetti cancerogeni sugli esseri umani (CHOONG *et alii*, 2007) e, in alcuni casi, l'avvelenamento da arsenico è stato così importante da destare l'attenzione pubblica mondiale (es. Bangladesh, West Bangle, India, ecc.). LIANG *et alii* (2009) hanno riferito che l'As (III) è da 25 a 60 volte più tossico di As (V) e diverse centinaia di volte più tossico degli arsenici organici. Il presente studio ha contribuito a migliorare lo stato attuale delle conoscenze sull'azione e la capacità del *Rust Waste Sand* (RWS) per la rimozione dell'arsenico (III) dall'acqua, quindi per promuovere e potenziare ulteriori ricerche sempre mirate a rimuovere l'arsenico dall'acqua attraverso i rifiuti di *rust*.

L'articolo descrive alcuni esperimenti nei quali è stato usato il filtro *Rust Waste Sand* (RWS): il materiale filtrante è stato preparato con ruggine filtrata da un setaccio n. 30 ASTM e sabbia comune di FM 2.605 con un rapporto di 2: 1 in peso ed è stato eseguito un test in colonna per valutarne l'efficacia e l'idoneità. Sono stati condotti dieci cicli di prove in colonna per valutare le prestazioni dei mezzi filtranti RWS.

La rimozione dell'arsenico da parte dei mezzi filtranti RWS è stata significativa. L'efficienza nella rimozione dell'arsenico (III) dall'acqua, rispetto al tempo di contatto, ha mostrato risultati migliori per pH 6,5, seguito da pH 7,0 e pH 7,5. Per rimuovere il 50% di As (III) da un'acqua con pH 6,5, 7,0 e 7,5 il tempo di contatto è stato rispettivamente di 225, 290 e 350 s, mentre la sabbia rivestita con ossido di ferro (IOCS) ha richiesto 1.380 s per un'acqua con pH 7,5-7,8 (JOSHIL & CHAUDHUR, 1996). THIRUNAVUKKARASU *et alii* (2002), per migliorare la qualità di acque non depurate da arsenico, hanno studiato anche la rimozione dell'arsenico da acqua potabile, utilizzando sabbia rivestita con ossido di ferro (IOCS-1 e IOCS-2) e VAISHYA *et alii* (2003) hanno studiato la rimozione dell'arsenico dalle acque sotterranee mediante sabbia impregnata di ferro, sia per As (III) che per As (V) con dose di adsorbente = 10 g/L; forza ionica = 0,01 M NaNO₃ e pH = 7,1 ± 0,1 e l'efficienza di rimozione in entrambi i casi è risultata significativamente inferiore rispetto al presente studio.

I risultati da letteratura sulla rimozione dell'arsenico utilizzando materiali di adsorbimento a base di ferro provenienti da rifiuti o da inquinanti hanno mostrato un'efficienza di rimozione inferiore rispetto al filtro RWS (HSU *et alii*, 2007; VAISHYA & GUPTA 2003; ZHANG *et alii*, 2003; VAISHYA & GUPTA, 2004; GUPTA *et alii*, 2005; BENJAMIN *et alii*, 1996; THIRUNAVUKKARASU *et alii*, 2001; EDWARD *et alii*, 1989; ecc.).

Per i campioni con pH 6,5, 7,0 e 7,5, la concentrazione di arsenico è scesa al di sotto valore di 0,05 mg/L, che è lo standard del Bangladesh per l'acqua potabile, dopo 4, 5 e 6 cicli di filtrazione e con tempo di contratto rispettivamente di 225, 375 e 450 secondi. Il filtro RWS è più efficace nel rimuovere rapidamente As (III) dall'acqua rispetto alla sabbia rivestita con ossido di ferro e ad altri materiali di adsorbimento a base di ferro. La superficie della goethite (FeOOH) e dell'ematite (Fe₂O₃) può essere maggiore rispetto ad altri materiali a base di ferro a causa dell'introduzione di materiale minerale a base di ematite superiore (Fe₂O₃nH₂O) come ruggine nei materiali filtranti (BENJAMIN *et alii*, 1996; THIRUNAVUKKARASU *et alii*, 2002), questo potrebbe essere il motivo principale della rimozione significativa dell'arsenico. Inoltre, durante la filtrazione possono formarsi micro flocculi di idrossido di ferro con conseguente assorbimento dell'arsenico. Questo fenomeno è poi responsabile di un'ulteriore rimozione di arsenico dalle acque. Inoltre, è stato osservato che in un determinato ciclo di filtrazione la lisciviazione totale del ferro dal filtro nell'acqua ha una concentrazione molto bassa rispetto alle linee guida standard.

I risultati degli studi sulle colonne hanno mostrato che i mezzi filtranti RWS, di facile utilizzo, potrebbero essere efficacemente utilizzati come tecnologia a bassissimo costo per diminuire il livello di concentrazione standard di As nell'acqua potabile. I rifiuti di ruggine sono presenti nelle barre provenienti dalla demolizione degli edifici, nell'industria dell'acciaio, nei magazzini, nei macchinari, ecc., ed anche se in piccola quantità, l'inquinamento indiscriminato di rifiuti di ruggine (RW) può causare un grave impatto ambientale, con conseguente inquinamento delle acque sotterranee e superficiali, l'inquinamento del suolo, ecc. Pertanto si può ritenere utile riutilizzare i rifiuti come la ruggine per ridurre gli impatti sull'ambiente.

ABSTRACT

The present study has contributed to the present state of knowledge on the effects of Rust Waste Sand (RWS) on removing arsenic from water. The main contributions of the research are evaluation and investigation the performance of Rust Waste Sand (RWS) on removing arsenic (III) from water, and enhancement of new research area and idea on removing arsenic from water using Rust waste.

This paper describes experiments in which Rust Waste Sand (RWS) filter was used to study the removal of arsenic. This filter media was prepared with rust passing through #30 no ASTM sieve and local sand of FM 2.605 with the ratio of 2:1 by weight, and column test was performed to assess the effectiveness and suitability. Ten cycles of column tests were conducted to evaluate the performance of RWS filter media.

The arsenic removal by RWS filter media with was significant. Performance of RWS filter in removing As (III) for pH of 6.5, 7.0 and 7.5 water with respect to contact time showed a better result for pH 6.5 and followed by pH 7.0 and pH 7.5. In removing 50% As (III) from water of pH 6.5, 7.0 and 7.5 the contact time were 225, 290 and 350 s respectively whereas iron-oxide coated sand (IOCS) required 1,380 s for the water of pH 7.5-7.8. RWS filter is more effective in removing As (III) from water abruptly than iron-oxide coated sand and others iron based adsorptions materials. Also, it had been investigated that at certain cycle of filtration total iron leaching from the filter in the water were noticed and this concentration was very many low than standard guidelines.

The results of column studies showed that RWS filter media could be effectively used as both very low cost and user friendly technology to achieve less than drinking water standard level of As concentration.

KEYWORDS: rust waste, arsenic, performance, new research area and idea, column test

INTRODUCTION

Safe water is human right is globally acknowledged. WHO and UNICEF disclosed through joint monitoring, four million people in Bangladesh lack access to safe water, most of findings were observed in Dhaka City, Bangladesh (ALI, 2019). The presence of heavy metals especially arsenic is of global concern because of possible adverse effects on human health. Among the heavy metals arsenic is considered as an important environmental pollutant with severe carcinogenic impacts on human beings (CHOONG *et alii*, 2007) and, in some case, arsenic poisoning is so severe that made worldwide headlines when reported (e.g. Bangladesh, West Bangle, India, etc.). LIANG *et alii* (2009) reported that As (III) 25 to 60 times more toxic than As (V), and several hundred times more toxic than organic arsenicals. Water containing arsenic concentration of 300-4,000 µg/L is not so rare (BERG *et alii*, 2001; HOSSAIN,

2006). The Environmental Protection Agency (EPA), World Health Organization (WHO), abreast of European Commission guidelines set up a limit of 10 µg/L (Council Directive 98/83/EC, 1998; WHO, 2011; USEPA, 2009), and Bangladesh Environmental Conservation Rules (ECR) sets up a limit of 50 µg/L (ECR, 1997) for arsenic concentration of drinking water.

Several studies have demonstrated that arsenic from water streams can be removed by various technologies or methods, such as precipitation (HERING *et alii*, 1997; WICKRAMASINGHE *et alii*, 2004; KARTINEN & MARTIN, 1995), sorption and ion-exchange (JEKEL, 1994; RAU *et alii*, 2003; SHEVADE & FORD, 2004; SINGH & PANT, 2004), coagulation and flocculation (HERING *et alii*, 1997; HAN *et alii*, 2002; KUMAR *et alii*, 2004; SONG *et alii*, 2006; BANERJI & CHAUDHARI, 2016), reverse osmosis (NING, 2002; KANG *et alii*, 2000; ILKER *et alii*, 2011; ABEJÓN *et alii*, 2015), membrane technique (HAN *et alii*, 2002; SATO *et alii*, 2002; SHIN, 2005), electro-dialysis (KUNDU & GUPTA, 2005), Biological process (KATSOYIANNIS & ZOUBOULIS, 2004; POKHREL & VIRARAGHAVAN, 2006), filter methods (NITZSCHE *et alii*, 2015; CHIEW *et alii*, 2009; MURPHY *et alii*, 2010; MANGOUA-ALLALI *et alii*, 2012; BAIG *et alii*, 2013) and abreast of lime softening (DUTTA & CHAUDHURI, 1991). Among the mentioned methods, coagulation and precipitation followed by filtration has been recognized as popular one, whereas reverse osmosis and electro-dialysis have also been found effective, but they are costly and water recovery is not optimized (USEPA, 2003). Currently, co-precipitation/adsorption methods are commonly introduced to meet the drinking water standards and prove a good efficiency to cost ratio for higher arsenic Concentration (VACLAVIKOVA *et alii*, 2007)

In column studies with iron-oxide coated sand (IOCS) and iron-oxide double coated sand was also observed thoroughly (BENJAMIN *et alii*, 1996; THIRUNAVUKKARASU *et alii*, 2002). ŞIK *et alii* (2017) was investigated the removals of both arsenite and arsenate from groundwater by electrocoagulation using iron ball anodes. Cylindrical packed-bed electrocoagulation (EC) reactor using Fe ball anodes were investigated in this study. Because of further suitability and effectiveness several studies have also demonstrated for arsenic removal by iron-oxide (HSU *et alii*, 2007; VAISHYA & GUPTA, 2003; ZHANG *et alii*, 2003; VAISHYA & GUPTA, 2004; GUPTA *et alii*, 2005). Though the sorptions of arsenic on HFO and IOCS have been studied in detail, no information is available on arsenic adsorption using rust waste.

Rust waste is available in demolish building rod surfaces, Steel industries, Machineries store, etc. Although small in quantity, indiscriminate littering of rust wastes (RWs) may cause serious environmental impact, such as groundwater and surface water pollution, soil pollution, etc. Therefore it can be considered necessary to reuse the rust waste for reducing the impacts on environment. The purpose of present study is to investigate the effectiveness and suitability of rust waste sand (RWS) filter media in removing arsenic from drinking water.

Ten cycles of column tests were conducted to evaluate the performance of RWS filter media.

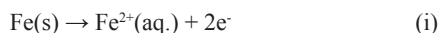
MATERIALS AND METHODS

Material collection and processing

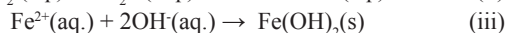
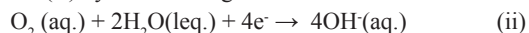
Rust waste

Rust ($\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$) Waste (RW) was collected from a local Machineries store at Gaipur, Bangladesh. The possible reactions that may be lead to the formation of rust on the surface of iron metal as follows:

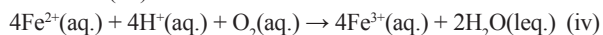
The iron atom can lose some electrons and become a positively charged ion.



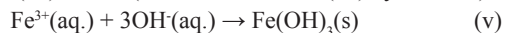
Hydroxide ions (OH^-) appear in water as the hydrogen ion concentration falls. They react with the iron (II) ions to produce insoluble iron (II) hydroxides or green rust:



The iron (II) ions also react with hydrogen ions and oxygen to produce iron (III) ions:



The iron (III) ions react with hydroxide ions again to produce hydrated iron (III) oxides (also known as iron (III) hydroxides):



The loose porous rust or $\text{Fe}(\text{OH})_3$ can slowly transform into a crystallized form written as $\text{Fe}_2\text{O}_3 \cdot n\text{H}_2\text{O}$ the familiar red-brown rust. The present study used this red- brown rust contains the mineral composition of hematite (Fe_2O_3).

Initially, the Rust waste was sieved by sieve (#30 no ASTM) to size of less than $600 \mu\text{m}$ because of providing higher surface areas, rinsed with deionized distilled water for five times and dried at 100°C for 24 hours before use.

Sand

Sand was collected from a local river of Sylhet, Bangladesh. Sand was sieved to a geometric mean size of 0.62 mm and the Finesse Modulus (FM) of 2.605, rinsed with deionized distilled water for three times and dried at 100°C for 24 hours before use.



Fig. 1 - Collected rust waste

Sieve No	Size	Residue (g)	Residue (%)	Cumulative (%)	FM
#4	4.75 mm	5	0.5	0.5	
#8	2.36 mm	55	5.5	6	
#16	1.18 mm	140	14	20	
#30	600 μm	289	28.9	48.9	2.605
#50	300 μm	376	37.6	86.5	
#100	150 μm	121	12.1	98.6	
#200	75 μm	13	n.d.	n.d.	
Pan	n.d.	1	n.d.	n.d.	
Total		1000		260.5	

Tab. 1 - Showing the finesse modulus analysis (FM) of sand (n.d. = not detected)

Water and standard solutions

Stock solution was prepared using a procedure similar to that of THIRUNAVUKKARASU *et alii* (2002), but influent concentration was lower for present study due to face lower concentration of arsenic by the peoples of Bangladesh (GEEN *et alii*, 2003). Arsenic standard solution for As (III) test by Atomic absorption spectrometry (AAS) of 1000 mg/L concentration was used as reference solution for preparing stock solution (ANEZAKI *et alii*, 1999). 0.1 mg/L of As (III) stock solution was prepared by pipetting 0.1 mL reference solution into a 1 L volumetric flask, and then the solution was made up to 1 L with distilled water. After preparation of stock solution the design concentration of As (III) was checked for each whenever it is prepared for filtration by AAS in the laboratory of Dhaka University of Engineering & Technology, Bangladesh. Immediately prepared stock solution was used in filtration for column test in lieu of storage sample for obtaining realistic results. All glass pipe and sample bottles were washed with a detergent solution, rinsed with tap water, and finally rinsed with distilled water for three times.

Filter preparation

The filter media used in this experiment was prepared with the mixture of rust waste passing through #30 no ASTM sieve and sand of FM 2.605 with the ratio of 2:1 by oven dry weight.

Then the mixture of Rust waste and Sand was filled in glass tube (11.5 mm diameter and 45 mm height of each) at 15 mm height, and the filter media washed with solution (0.2N NaOH) followed distilled water until fresh water effluent.

Column test

The column tests were conducted with three different pH of 6.5, 7.0 and 7.5 water.

The average flow rate to the column was 0.30 mL/s, and the head of water was kept at constant height during whole test for all columns. 10 cycles of down flow column tests were conducted to study the removal of As (III). Sample from the each column was collected at regular interval and analyzed for residual As (III) and total iron concentration.



Fig. 2 - Glass pipe

Iron and arsenic concentration analysis

Iron concentration of effluent was determined as per USEPA FerroVer Method (0.02 to 3.0 mg/L range) using DR-5000 UV-Vis Spectrophotometer of HACH Company, USA, and Atomic absorption spectrometry (AAS) was used to determine the residue As (III) concentration of the effluent. This study used these modern devices and given maximum intentness due to obtain realistic results in the environmental laboratory of Dhaka University of Engineering & Technology, Bangladesh.

RESULT AND DISCUSSION

Arsenic removal

The arsenic removal by RWS filter media with was significant. Performance of RWS filter media in removing As (III) for pH of 6.5, 7.0 and 7.5 water is shown in Table 3, 4, 5 and 6 and figure 4. Arsenic (III) removal efficiency with respect to contact time showed a better result for pH 6.5 and followed by pH 7.0 and pH 7.5. In removing 50% As (III) from water of pH 6.5, 7.0 and 7.5 the contact time were 225, 290 and 350 s respectively, whereas iron-oxide coated sand (IOCS) required 1,380 s for the water of pH 7.5-7.8 (JOSHIL & CHAUDHUR, 1996). THIRUNAVUKKARASU *et alii* (2002), also investigated the arsenic removal of drinking water using iron-oxide coated sand (IOCS-1 and IOCS-2) for further improvement in removing arsenic from raw water and VAISHYA *et alii* (2003) investigated arsenic Removal from Groundwater by Iron Impregnated Sand for both As (III) & As (V) with adsorbent dose=10 g/L; ionic strength = 0.01 M NaNO₃, and pH =7.1±0.1 and the removal efficiency for both cases were significance lower than present study. The literature review outcomes on arsenic removal using iron base adsorption materials either wastes or virgin showed lower removal efficiency than RWS filter (HSU *et alii*, 2007; VAISHYA & GUPTA, 2003; ZHANG *et alii*, 2003; VAISHYA & GUPTA, 2004; GUPTA *et alii*, 2005; BENJAMIN *et alii*, 1996; THIRUNAVUKKARASU *et alii*, 2001; EDWARD *et alii*, 1989; etc.).

The surface area of goethite (FeOOH) and hematite

Parameters	Present study	THIRUNAVUKKARASU <i>et alii</i> , 2002	JOSHIL & CHAUDHUR, 1996
Diameter of pipe (mm)	11.50	16	11
Filter depth (mm)	150	400	525
Average flow rate (mL/s)	0.30	0.358	0.0166
Sand (Mean Size)	0.62	0.60-0.80	0.49
No. of column test	10	5	10
Filter media	rust waste and sand	double iron-oxide coated sand	iron-oxide coated sand

Tab. 2 - Physical properties of filter and its comparison with relevant studies



Fig. 3 - Showing a part of column test and collected effluent in air tight plastic can

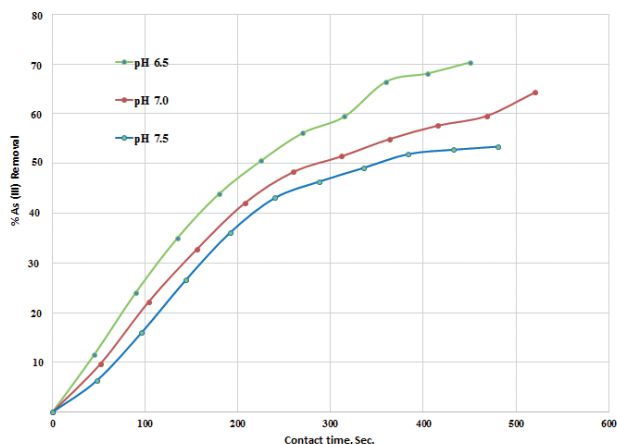
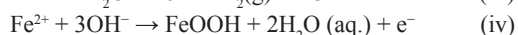
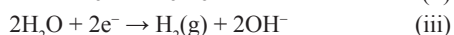
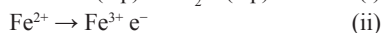
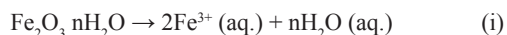
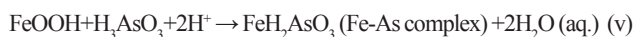


Fig. 4 - As (III) removal with respect to time for water of pH 6.5, 7.0 & 7.5

(Fe₂O₃) may be higher than others iron based materials because of introducing higher hematite based minerals material (Fe₂O₃nH₂O) rust in filter media (BENJAMIN *et alii*, 1996; THIRUNAVUKKARASU *et alii*, 2002), this is may be the main reasons in significant removal of arsenic. Furthermore, ferric hydroxide micro flocs may be formed during filtration and arsenic may also be absorbed onto flocs, this is may be another reason. The possible reactions that may be lead to the formation of goethite (FeOOH) from hematite based minerals material (Fe₂O₃nH₂O) rust may be as follows:



Arsenite adsorb at oxyhydroxide surface by forming complexes with the surface sites (EDWARDS, 1994). The reactions between arsenic species and goethite may be represented as follows:



For the sample of pH 6.5, the arsenic concentration had been dropped below the range of 0.05 mg/L which is the Bangladesh standard for drinking water after 4 cycles of filtration with contract time 225 s. In case of pH 7.0, the arsenic concentration had been dropped below the range of 0.05 mg/L after 5 cycles of filtration with contract time 375 s whereas pH 6.5 water sample requires lower 225 s contact time.

To achieve the concentration of effluent below than 0.05 mg/L in case of pH 7.5 water requires 450 s with 6 cycles of filtration which is higher than that of required for pH 7.0 and pH 6.5. Therefore it can be disclosed that RWS filter media is more effective for lower pH value and its effective's decreases gradually with increasing pH value of water and this approach was similar to the experimental outcomes of Hsu *et alii* (2007). In this study, adsorption capacities of As (III) decreased from

Contact time (s)	As (III) removal (mg)	Removal (%)
0	0	0
45	0.0105	11.5
90	0.0219	24.1
135	0.0319	35.1
180	0.04	44.0
225	0.042	50.5
270	0.0511	56.2
315	0.0541	59.5
360	0.0541	66.5
405	0.0498	68.1
450	0.0509	70.3

Tab. 3 - As (III) removal with respect to time for water of pH 6.5

Contact time (s)	As (III) removal (mg)	Removal (%)
0	0	0
52	0.0087	9.8
104	0.0198	22.2
156	0.0292	32.8
208	0.0375	42.1
260	0.043	48.3
312	0.0458	51.5
364	0.0489	54.9
416	0.0513	57.6
468	0.053	59.6
520	0.0572	64.3

Tab. 4 - As (III) removal with respect to time for water of pH 7.0

Contact time (s)	As (III) removal (mg)	Removal (%)
0	0	0
48	0.006	6.4
96	0.015	16.0
144	0.025	26.6
192	0.034	36.2
240	0.0405	43.1
288	0.0436	46.4
336	0.0462	49.1
384	0.0488	51.9
432	0.0496	52.8
480	0.0502	53.4

Tab. 5 - As (III) removal with respect to time for water of pH 7.5

64 to 50 µg/L when the pH increased from 6.5 to 7.5 whereas, Hsu *et alii* (2007) showed adsorption capacities of As (III) decreased from 8.7 to 6.7 µg/L when the final pH increased from 6.3 to 7.1.

Therefore, it may be concluded that RWS filter is more effective due to rust contain hematite menarl (Fe₂O₃) in removing As (III) from water abruptly than iron-oxide coated sand and others iron based adsorptions materials.

Total iron leaching

Also, it had been investigated that at certain cycle of filtration leaching from the filter in the water were noticed and this leaching trends was not detected in case of iron-oxide coated sand (IOCS) filter (JOSHIL & CHAUDHUR, 1996). Some researchers performed leaching test to measure the release of total iron from the surface of IOCS under various initial pH values ranging from 5 to 8 (RUANGCHAINIKOM *et alii* (2005), RUANGCHAINIKOM (2006) and some researchers didn't investigate the leaching or releasing of iron in the solution (THIRUNAVUKKARASU *et alii*, 2002).

Hsu *et alii* (2007) investigated the total iron leaching during the removal of As (V) and As (III) by reclaimed iron-oxide coated sands and observed release of total iron from IOCS into the solution, the maximum concentration of total iron in the solution was 2.6 mg/L at pH 5, with a leaching ratio of 0.011% after 8 h. World Health Organization (WHO) sets up a limit of 0.3 mg/L (WHO, 2011), and Bangladesh Environmental Conservation Rules (ECR) sets up a limit of 0.3-1.0 mg/L (ECR, 1997) for total iron concentration of drinking water. The present study observed leaching of iron in the solution from rust waste at certain cycle of filtration and this concentration was very many low than standard guidelines.

Filtration (cycle)	Iron leaching (ppm) pH (6.5)	Iron leaching (ppm) pH (7.0)	Iron leaching (ppm) pH (7.5)
01	0.06	-	-
02	-	-	-
03	-	-	-
04	-	-	-
05	0.06	0.06	0.05
06	-	-	-
07	-	-	-
08	-	-	-
09	-	-	-
10	0.06	0.05	0.05

Tab. 6 - Total iron leaching from rust waste during filtration

CONCLUSIONS

In the laboratory study, Rust Waste Sand (RWS) showed promise as a medium for use in small and very low cost system for removing As (III) in developing areas of the world. The present study was limited scope in the removal of arsenic because of financial crisis for experimental purposes. It did not address the potentials effect of some important factors, such as possible selectivity of arsenic (III) and arsenic (V) over one another for removal, water pH,

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concentration and type of competing anions, and cations that sorb and affect surface charge of the medium or form soluble arsenic complexes, and long term effects on performance.

The present study has contributed to the present state of knowledge on the effects of Rust Waste Sand (RWS) on removing arsenic from water. The main contributions of the research are evaluation and investigation the performance of Rust Waste Sand (RWS) on removing arsenic from water, and enhancement of new research area and idea on removing arsenic from water using Rust waste.

The major conclusion base on study result may be drawn: the surface area of goethite (FeOOH) and hematite (Fe₂O₃) may be higher than others iron based materials, this is may be main reasons in significant removal of arsenic, furthermore, ferric hydroxide micro flocs may also be formed during filtration and arsenic may be absorbed onto flocs, this is may be another reason;

performance of RWS filter in removing As (III) for pH of 6.5, 7.0 and 7.5 water with respect to contact time showed a better result for pH 6.5 and followed by pH 7.0 and pH 7.5;

in removing 50% As (III) from water of pH 6.5, 7.0 and 7.5 the contact time were 225, 290 and 350 s respectively whereas iron-oxide coated sand (IOCS) required 1,380 s for the water of pH 7.5-7.8;

for the samples of pH 6.5, 7.0 and 7.5, the arsenic concentration had been dropped below the range of 0.05 mg/L which is the Bangladesh standard for drinking water after 4, 5 and 6 cycles of filtration and with contact time 225 s, 375 s and 450 s respectively;

RWS filter is more effective in removing As (III) from water abruptly than iron-oxide coated sand and others iron based adsorptions materials;

at certain cycle of filtration iron leaching from the filter in the water was noticed and this concentration was very many low than standard guidelines of Bangladesh standard, WHO and also USEPA.

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