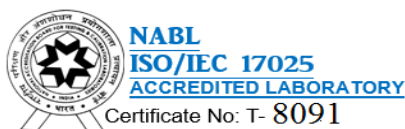


Laboratory Scale Studies on *Arsenic and Fluoride* Removal Efficiency Individually on Supplied HIX-Nano100 &HIX-Nano200

Sponsor
WIST WATER SOLUTIONS PRIVATE LIMITED
(Brand name “drinkwell”)
78 Biren Roy Road West, Kolkata 700061, W.B., India

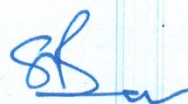
June 2019



CSIR-INSTITUTE OF MINERALS & MATERIALS TECHNOLOGY
(Council of Scientific & Industrial Research)
Bhubaneswar -751 013

FOREWORD

It is a great pleasure for me to forward the final report (Dec 2018 - May 2019) on the project entitled "Laboratory scale studies on arsenic and fluoride removal efficiency from Ground water individually on supplied HIX-Nanomaterials resin in test set-up by WIST WATER SOLUTIONS PVT. LTD." The report incorporates the data generated on the water collected after passing through HIX-Nano100 & HIX-Nano200 resin for arsenic and fluoride respectively. The report brings out the efficiency of said resins as investigated during lab scale experiment for the period Dec 2018 - May 2019. The report will be immensely useful to all concerned for related studies and understanding on efficiency of said resins.



Prof. Siddhasatwa Basu
Director, CSIR-IMMT

प्राक्कथन

“विस्ट वाटर सोल्यूशन्स प्राइवेट लिमिटेड द्वारा परीक्षण सेट अप में आपूर्ति किए गए HIX-नैनोपदार्थों पर भूमिगत जल से पृथक् रूप से आर्सेनिक और फ्लोराइड के निष्कासन क्षमता की प्रयोगशाला पैमाने पर अध्ययन” शीर्षक परियोजना की अंतिम रिपोर्ट को अंग्रेषित करना मेरे लिए खुशी की बात है। इस रिपोर्ट में क्रमशः आर्सेनिक और फ्लोराइड के लिए HIX-Nano100 & HIX-Nano 200 रेजिन के माध्यम से पारित किए जाने के बाद संग्रह किए गए जल पर उत्पन्न ऑकड़ों को शामिल किया गया है। दिसम्बर 2018 से मई 2019 अवधि के लिए प्रयोगशाला पैमाने पर जांच की गई उक्त रेजिनों की क्षमता को दर्शाता है। यह रिपोर्ट उक्त रेजिनों की क्षमता को समझने और उसके अध्ययन से संबंधित व्यक्तियों के लिए काफी उपयोगी सिद्ध होगी।

प्रो. शुद्धसत्व बसु

निदेशक, सीएसआईआर- आईएमएमटी

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The team is grateful to Prof. Suddhasatwa Basu, Director, CSIR-Institute of Minerals and Materials Technology, Bhubaneswar for his keen interest and constant encouragement.


19/06/19

Dr Arakshita Majhi
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TEAM OF INVESTIGATORS

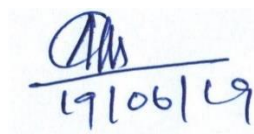
DR. A. MAJHI (Project Leader)

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Dr R BOOPATHY

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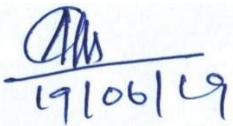
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Handwritten signature of Dr. Arakshita Majhi, dated 19/06/19.

Dr Arakshita Majhi
Sr.Scientist
Project Leader

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CHAPTER-I

*Laboratory scale studies on arsenic removal efficiency individually on
supplied HIX-Nano100 resin*

by

WIST WATER SOLUTIONS PVT. LTD.

1.1. Introduction:

Arsenic contamination of surface and subsurface waters is reported in many parts of the world and is considered a global issue. As a naturally occurring toxic substance in the earth's crust, arsenic enters into aquifers and wells through natural processes, and to the water cycle as a result of anthropogenic activities. Arsenic contamination of subsurface waters is believed to be geological. High arsenic concentrations may result from dissolution of, or desorption from iron oxide, and oxidation of arsenic pyrites. The severity of arsenic pollution of groundwater is reported in Bangladesh, where most of the people rely on tube wells as a source of drinking water. It is estimated that 30 to 70 million people in Bangladesh are at risk due to the exposure of arsenic contaminated water. In **India**, the states of West Bengal, Jharkhand, Bihar, Uttar Pradesh, Assam, Manipur and Chhattisgarh are reported to be **most** affected by **arsenic contamination** of groundwater above the permissible level.

Ingestion of inorganic arsenic can result in both cancer (skin, lung and urinary bladder) and non-cancer effects (NRC, 1999). The acute and chronic toxicity effects of the ingestion of arsenic contaminated water have been well documented. Population-based studies showed that arsenite [As (III)] and arsenate [As (V)] may adversely affect several organs in the human body.

The solutions of Arsenic Trioxide form weak acids with water. This is due to the fact that the compound is an amphoteric oxide. It is soluble in alkaline solutions and gives Arsenites. Arsenic Trioxide has high solubility in Hydrochloric Acid (HCl) and finally gives Arsenic Trichloride and concentrated acid.

In chemistry, an amphoteric compound is a molecule or ion that can react both as an acid and as a base. Many metals (such as copper, zinc, tin, lead, aluminium, and beryllium) form amphoteric oxides or hydroxides. Amphoterism depends on the oxidation states of the oxide.

The contamination of a drinking water source by arsenic can result from either natural or human activities. Arsenic is an element that occurs naturally in rocks and soil, water, air, plants, and animals. Arsenic in groundwater generally occurs in two forms, pentavalent arsenic (also known as Arsenic V, As^{+5} , or arsenate) and trivalent arsenic, (also known as Arsenic; Arsenic^{+3} , Arsenic; Arsenic III, or arsenite). Trivalent arsenic is generally more difficult to remove from drinking water than pentavalent arsenic. Further, preliminary research has found Arsenic III occurring at higher concentrations than Arsenic V.

Arsenic pentoxide is the inorganic compound with the formula As_2O_5 . This glassy, white, deliquescent solid is relatively unstable, consistent with the rarity of the As (V) oxidation state. More common, and far more important commercially, is arsenic (III) oxide (As_2O_3). All arsenic compounds are highly toxic and thus find only limited commercial applications.

HIX-Nano Media: Hybrid Ion Exchange Nanotechnology Media which is commonly known as HIX-Nano Media. WIST WATER SOLUTIONS PVT LTD is licensed to manufacture HIX-Nano following a licensing agreement/ right from Dr. Arup K. Sengupta, Lehigh University, USA who originally developed HIX-Nano (US patent No. 9,120,093 B2, September 1, 2015). The variety **HIX-Nano100** is Macroporous, spherical polymeric ion exchange resin beads loaded with nanoparticles of iron, zirconium oxides inside the beads. This media is suitable for removal of arsenic species from contaminated groundwater and other water. The media is reusable for cycles through regeneration. Particle size: 0.3 - 1.2 mm, Appearance: Dark Brown/ Brown with reddish tint, Bulk density: 0.7 - 0.76 kg/l, Capacity (As removal) - about 10 mg/g.

1.2. Experimental

Treatment unit filled with **HIX-Nano100** resin of capacity 100 liter/hour approximately was supplied by WIST WATER SOLUTIONS PVT LTD and installed at CSIR-IMMT. Tap water was collected from CSIR-IMMT overhead tank through ground water pumping and about up to 0.3 mg/L (300 ppb) of synthetic arsenic contaminated water was prepared for this study.

1.2.1 Methods:

Synthetic arsenic contaminated water was passed through **HIX-Nano100** resin at 100 L/h for arsenic removal study for 32 days as per the design and laboratory plant setup provided by WIST WATER SOLUTIONS PVT LTD. The experimental data are given in Table-1.1. The key water parameters of feed water and HIX-Nano 100 treated water were characterized as per IS: 10500:2012 standards test methods. The results of key parameters are given in Table- 1.2. The resin packed bed laboratory setup is back flushed periodically.

1.3. Results and discussion

Generally arsenic exists in water in both trivalent and pentavalent form. Both the type of arsenic are harmful to humans, but trivalent **arsenic** is **more** harmful and **difficult to remove from water**. As^{+3} can be converted into pentavalent **arsenic** in the presence of an effective oxidant such as free chlorine. The presence of sulfate, TDS, selenium, fluoride, and nitrate compete with arsenic on removal and can affect long run. Passage through a series of columns could improve removal and decrease regeneration frequency. Suspended solids and

precipitated iron can cause clogging of the bed. Systems containing high levels of these constituents may require pretreatment.

From the **Table-1.1**, it is observed that arsenates and arsenites are being adsorbed by nanoscale iron & zirconium oxide present in the hybrid anion exchange polymeric resin i.e. **HIX-Nano100**. Figure 1.1 displays arsenic profiles showing arsenic removal by HIX-Nano 100 resin in packed bed column. However, for continuous operation, periodic back wash is required.

Table-1.1: Removal of arsenic using HIX-Nano100 in synthetic water

Date	Arsenic content of water before filtration, ppb	Arsenic content of water after filtration, ppb	Regeneration	Flow rate /Hour	Flow time Hour
14.02.2019	210	3	No regeneration Done	100 litre	4
15.02.2019	212	8		100 litre	4
20.02.2019	125	6		100 litre	4
21.02.2019	254	16		100 litre	4
22.02.2019	214	12		100 litre	4
23.02.2019	196	8		100 litre	4
25.02.2019	184	6		100 litre	4
26.02.2019	194	8		100 litre	4
27.02.2019	186	7		100 litre	4
28.02.2019	296	11		100 litre	4
01.03.2019	219	13		100 litre	4
04.03.2019	112	3		100 litre	4
05.03.2019	106	5		100 litre	4
06.03.2019	221	9		100 litre	4
07.03.2019	098	1		100 litre	4
11.03.2019	096	2		100 litre	4
12.03.2019	145	7		100 litre	4
14.03.2019	069	4		100 litre	4
15.03.2019	084	8		100 litre	4
20.03.2019	125	5		100 litre	4
21.03.2019	254	17		100 litre	4
22.03.2019	214	11		100 litre	4
23.03.2019	196	7		100 litre	4
25.03.2019	184	8		100 litre	4
26.03.2019	144	7		100 litre	4
27.03.2019	186	7.5		100 litre	4
28.03.2019	296	9		100 litre	4
01.04.2019	219	10		100 litre	4
04.04.2019	112	3		100 litre	4
05.04.2019	106	5		100 litre	4
06.04.2019	281	11		100 litre	4
09.04.2019	095	1		100 litre	4

N: B-About up to 300 ppb of arsenic contaminated water is synthetically prepared with tap water
Source of tap water: CSIR-IMMT.

Table-1.2: Key parameters of synthetic arsenic containing water (before and after passing through resin) as per IS: 10500:2012

PARAMETERS	14.02.2019		15.02.2019		20.02.2019		21.02.2019		22.02.2019		23.02.2019		25.02.2019		26.02.2019	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
pH	6.23	6.66	7.05	7.58	7.09	7.63	6.84	7.52	6.94	7.43	6.53	7.05	6.81	7.26	6.45	6.72
COLOR	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
TDS, mg/l	173	176	175	174	178	176	176	175	178	176	174	167	178	175	176	170
TSS, mg/l	1.56	0.45	2.36	0.78	2.69	0.62	3.64	0.16	2.51	0.23	3.14	0.14	1.96	0.18	2.16	0.26
Conductivity,µs/cm	346	352	349	348	356	352	351	349	356	351	348	334	356	350	351	340
Turbidity, NTU	0.18	0.02	0.26	0.02	0.15	0.02	0.18	0.02	0.16	0.02	0.23	0.02	0.26	0.02	0.14	0.02
Alkalinity, mg/l	6.0	24.0	7.0	26.0	6.0	25.0	6.0	24.0	6.0	24.0	7.0	28.0	7.0	28.0	6.0	26.0
Hardness, mg/l	26.02	26.02	24.02	26.02	24.02	24.02	26.02	26.02	24.02	26.02	28.02	28.02	28.02	28.02	24.02	26.02
Sulphates, mg/l	2.45	2.36	2.56	2.34	2.51	2.41	2.56	2.45	2.78	2.54	3.12	3.14	3.52	3.46	3.41	3.52
Fluoride, mg/l	0.09	0.08	0.09	0.09	0.06	0.06	0.08	0.08	0.08	0.09	0.06	0.08	0.08	0.08	0.08	0.09
Chloride, mg/l	28.0	25.0	28.0	26.0	27.0	24.0	28.0	26.0	28.0	26.0	27.0	25.0	27.0	24.0	28.0	26.0
Carbonate, mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Calcium, mg/l	5.6	5.6	5.6	5.6	4.8	4.8	5.6	5.6	5.6	5.6	5.6	5.6	4.8	4.8	5.6	5.6
Magnesium, mg/l	2.93	2.93	2.44	2.93	2.93	2.93	2.93	2.93	2.44	2.93	3.42	3.42	3.91	3.91	3.42	3.42
Sodium, mg/l	16.54	15.63	18.62	17.42	18.42	15.62	15.63	14.25	18.52	16.47	17.45	16.94	16.74	15.45	16.39	15.46
Potassium, mg/l	0.05	0.02	0.04	0.02	0.06	0.03	0.05	0.02	0.04	0.02	0.06	0.02	0.04	0.02	0.04	0.02

PARAMETERS	28.02.2019		01.03.2019		04.03.2019		05.03.2019		06.03.2019		07.03.2019		11.03.2019		12.03.2019	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
pH	6.43	6.88	6.41	6.75	6.59	7.01	6.49	6.97	6.56	6.95	6.59	6.82	6.52	6.79	6.53	6.82
COLOR	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
TDS, mg/l	167	168	177	245	175	255	197	248	181	249	174	257	176	249	176	246
TSS, mg/l	2.74	0.18	1.69	0.26	2.65	0.34	3.15	0.41	2.85	0.24	3.61	0.52	2.45	0.31	3.69	0.46
Conductivity,µs/cm	334	336	353	490	349	510	393	496	362	498	348	514	352	498	351	491
Turbidity, NTU	0.19	0.02	0.19	0.02	0.20	0.02	0.18	0.02	0.18	0.02	0.16	0.02	0.09	0.02	0.15	0.02
Alkalinity, mg/l	6.0	24.0	12.0	60.0	11.0	58.0	10.0	58.0	12.0	58.0	12.0	58.0	14.0	60.0	12.0	60.0
Hardness, mg/l	24.02	26.02	54.04	56.04	56.04	56.04	54.04	56.04	54.04	56.04	56.04	56.04	54.04	54.04	56.04	56.04
Sulphates, mg/l	3.12	3.06	2.85	2.96	2.74	2.85	2.78	2.63	2.98	3.01	2.84	2.96	2.74	2.78	2.96	2.98
Fluoride, mg/l	0.09	0.09	0.08	0.08	0.09	0.08	0.08	0.09	0.09	0.09	0.09	0.08	0.09	0.08	0.08	0.08
Chloride, mg/l	27.0	25.0	27.0	24.0	28.0	25.0	28.0	25.0	28.0	26.0	28.0	25.0	28.0	26.0	28.0	25.0
Carbonate, mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Calcium, mg/l	5.6	5.6	13.62	13.62	13.62	13.62	14.42	14.42	14.42	14.42	14.42	13.62	14.42	14.42	14.42	14.42
Magnesium, mg/l	2.44	2.93	4.88	5.37	5.37	5.37	4.40	4.88	4.40	4.88	4.88	5.37	4.40	4.40	4.88	4.88
Sodium, mg/l	16.13	15.62	16.17	15.62	15.95	15.58	15.62	15.13	16.12	15.42	16.23	15.48	15.82	14.96	15.29	14.52
Potassium, mg/l	0.06	0.02	0.04	0.02	0.05	0.03	0.06	0.01	0.04	0.01	0.05	0.02	0.06	0.02	0.04	0.01

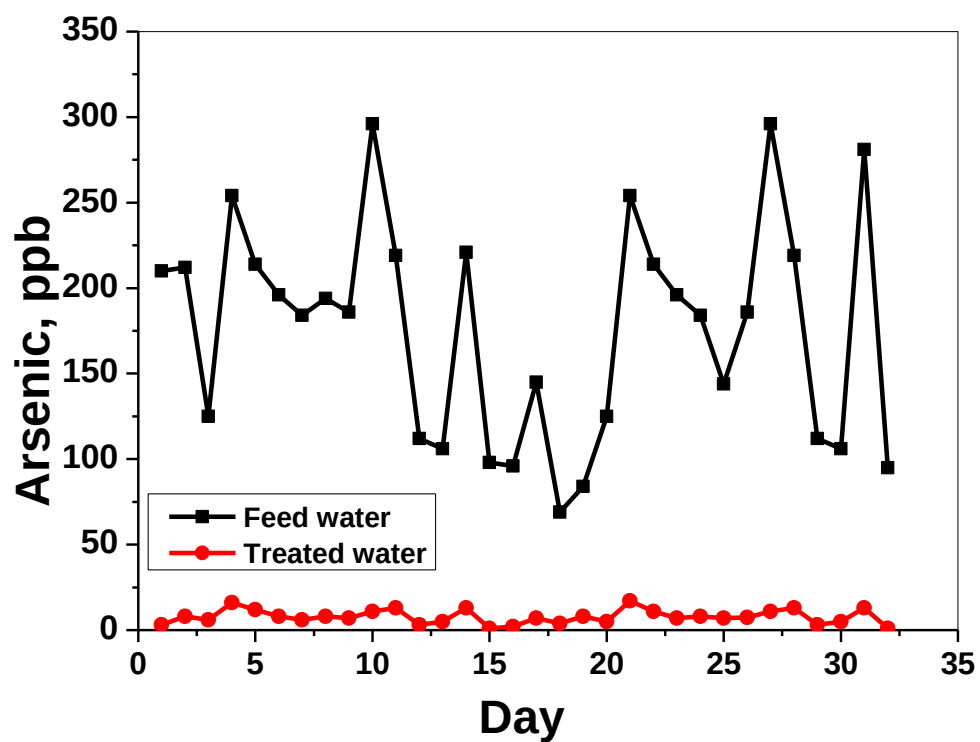


Figure-1.1: Removal of Arsenic by HIX-Nano 100 resin of WIST Water Solutions Pvt Ltd. in a packed bed column from synthetically prepared arsenic contaminated water (**Conditions:** Flow rate, 100 L/h; run time per day, 4 h)

1.4. Conclusion

From the study the following conclusion may be drawn.

1. **HIX-Nano 100** resin and the system set-up provided by M/S **WIST WATER SOLUTIONS PVT LTD** has been tested for removal of total arsenic from synthetic water contains arsenic in the range of 69 ppb to 296 ppb.
2. The removal efficiency of **HIX-Nano 100** for removal of arsenic has been tested only for synthetically prepared arsenic contaminated water. Since actual arsenic contaminated water from is not available at Bhubaneswar. The synthetic water was prepared by taking CSIR-IMMT ground water.
3. **HIX-Nano 100** is found to remove arsenic satisfactorily within the limit of test conditions.
4. Periodic monitoring of arsenic removal plant is required and regeneration/change of media may be required following checking of arsenic level in treated water
5. At the time of installation the arsenic removal plant, fresh **HIX-Nano 100** resin must be used and periodic washing may be required.
6. The process parameters of water in the report has been carried out as per BIS standard IS 10500:2012

N:B- This test report is the property of CSIR-IMMT and only applicable to **WIST WATER SOLUTIONS PVT LTD**. This report cannot be shared/sub-contracted with any other parties/firms/person without prior permission of CSIR-IMMT



सी.एस.आइ.आर - खनिज एवं पदार्थ प्रौद्योगिकी संस्थान
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No. : 1129/E & S/SSP- 347/June/2019

To Whom It May Concern

This is to certify that CSIR-IMMT Bhubaneswar tested hybrid ion exchange nanotechnology media **HIX-Nano 100** of WIST WATER SOLUTIONS PVT. LTD. (brand name "drinkwell"), 78 Biren Roy Road West, Kolkata 70061, for arsenic removal at CSIR-IMMT, Bhubaneswar.

Arsenic removal column set-up filled with resin **HIX-Nano 100** of WIST WATER SOLUTIONS PVT LTD, was tested using feed water contaminated with different level of arsenic up to 0.3 mg/l (300 ppb). The media HIX-Nano 100 was found to remove arsenic efficiently within the permissible limit as per BIS 10500-2012.

Arsenic removal efficiency was tested in the laboratory scale with arsenic contaminated water synthetically prepared using CSIR-IMMT groundwater.

N:B-This is only applicable to WIST WATER SOLUTIONS PVT. LTD.

(Signature)
19/06/19

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CHAPTER-II

*Laboratory scale studies on fluoride removal efficiency individually
on supplied HIX-Nano 200 resin media*

by

WIST WATER SOLUTIONS PVT. LTD.

2.1 Introduction:

Fluoride is found in both wastewater as well as Ground water nowadays. Significant amount of Fluoride is found in ground water in different locations where fluoride concentration has risen till 10 ppm. This causes severe diseases like Brain Damage and it also affects Pineal Gland, thyroid function and arthritic syndromes. It also damages Bone and even causes reproductive problems.

Treatment of fluoride from the drinking water stream is mandatory and it requires be reducing to less than 1 ppm or 1 mg /L. As per our Indian Standards Specification for drinking water IS 10500: 2012 the fluoride range should be below 1 ppm.

The present detailed laboratory study of fluoride removal unit has been aimed to determine the removal efficiency of fluoride from fluoride contaminated water by **HIX-Nano 200** resin in a fluoride removal unit. **WIST WATER SOLUTIONS PVT LTD** had supplied the fluoride removal unit capacity of about 100 liters/hour and **HIX-Nano 200** media to CSIR-IMMT Bhubaneswar. Such study on a removal efficiency of fluoride shall give an idea about the **HIX-Nano 200** resin media.

HIX-Nano Media: Hybrid Ion Exchange Nanotechnology Media which is commonly known as HIX-Nano Media. **WIST WATER SOLUTIONS PVT LTD** is licensed to manufacture HIX-Nano media following a licensing agreement/ right from Dr. Arup K. Sengupta, Lehigh University, USA who originally developed HIX-Nano (US patent No. 9,120,093 B2, September 1, 2015). The variety **HIX-Nano200** is Macroporous, spherical polymeric ion exchange resin beads loaded with nanoparticles of zirconium oxides or aluminium species inside ion exchange resin. HIX-Nano 200 is suitable for removal of fluoride from contaminated groundwater or other. This media is durable and reusable for multiple-cycles through regeneration. Particle size: 0.3 mm to 1.2 mm, appearance: off-white or grey-brown, bulk density: 0.72 – 0.82 kg/l, capacity: up to 15 mg/gm. **WIST WATER SOLUTIONS PVT. LTD.** (brand name “drinkwell”) has provided the media HIX-Nano 200 and test set-up. CSIR-IMMT has not tested properties, composition of the HIX-Nano 200 resin; the lab has only studied on removal efficiency of fluoride from water.

2.2. Experimental:

2.2.1 Materials:

HIX-Nano 200 media and the plant of capacity 100 liter/hr was supplied by **WIST WATER SOLUTIONS PVT LTD** (brand name “drinkwell”) and installed at CSIR-IMMT. Tap

water was collected from CSIR-IMMT and synthetic fluoride contaminated water (up to 10 mg/l approximately) was prepared for this study. Further actual fluoride contaminated water was collected from Balsinghapur village of Nayagarh district of Odisha. The fluoride content was about 3.7 mg/l. The source of this fluoride contaminated water was dug well.

2.2.2 Methods:

Initially synthetic fluoride contaminated water was passed through **HIX-Nano 200** resin at 100 lit/h in fluoride removal plant setup provided by WIST WATER SOLUTIONS PVT LTD for 28 days. The observed experimental data are given in Table-2.1. Further to check the efficiency of **HIX-Nano 200** resin the actual contaminated water collected from dug well collected from Balsinghapur village of Nayagarh district of Odisha was passed through **HIX-Nano 200** resin in same laboratory scale plant for four days for which result is shown in Table-2.2. The key process parameters of synthetic feed and the treated water were characterized as per IS: 10500:2012 standards methods. The results are given in Table 2.3 & 2.4 respectively. During the experiment, the column with **HIX-Nano 200** was back washed from time to time.

2.3. Results & discussion:

From the Table-2.1 & 2.2, it is observed that **HIX-Nano 200** resin removes the fluoride from both synthetic and actual contaminated water quite efficiently. Periodic regeneration of the media HIX-Nano 200 may be required following exhaustion of removal capacity although regeneration was not done for the current study. It has been observed that other parameters excluding fluoride content are also partially influenced. From the Table-2.3 it is observed that pH of the output water has increased than input water though the same is within the recommended limit of drinking water (IS: 10500). Further the alkalinity of the treated was found to increase this may be reason for the increase in solution pH after treatment. Since the pH is directly proportional to total alkalinity. However, fluoride removal efficiency is good within the pH range from 5.0 to 9.0. In order to understand resin performance a study carried out for the actual ground water sample collected from fluoride contaminated location Balashingpur, Odisha and the results are shown in Table-2.4. The results shows that the fluoride is removed significantly from the initial 3.75 mg/L to less than 0.56 which is below the permissible concentration level as per the WHO recommended limit.

Table-2.1: Performance evaluation of Fluoride removal using HIX-Nano 200 resin media for synthetic water*

Date	Fluoride content, mg/L before passing through resin, mg/l	Fluoride content mg/L after passing through resin, mg/l	BIS (10500) Limit for Fluoride mg/l	Flow rate, Litre/hr	Flow time In Hour	Regeneration
01.12.2018	6.45	0.04	Acceptable limit – 1 Max. permissible limit – 1.5	100	4	No regeneration done
03.12.2018	5.81	0.03		100	4	
04.12.2018	6.42	0.04		100	4	
05.12.2018	5.63	0.02		100	4	
06.12.2018	6.23	0.04		100	4	
07.12.2018	5.89	0.03		100	4	
10.12.2018	4.72	0.04		100	4	
11.12.2018	5.16	0.03		100	4	
12.12.2018	6.15	0.04		100	4	
13.12.2018	6.89	0.03		100	4	
14.02.2019	5.6	0.04		100	4	
15.02.2019	6.2	0.03		100	4	
20.02.2019	5.8	0.04		100	4	
21.02.2019	7.3	0.04		100	4	
22.02.2019	7.4	0.02		100	4	
23.02.2019	6.8	0.03		100	4	
25.02.2019	6.8	0.02		100	4	
26.02.2019	5.9	0.04		100	4	
27.02.2019	6.2	0.03		100	4	
28.02.2019	6.4	0.03		100	4	
01.03.2019	8.2	0.04		100	4	
04.03.2019	8.6	0.02		100	4	
05.03.2019	9.9	0.03		100	4	
06.03.2019	8.7	0.03		100	4	
07.03.2019	9.6	0.04		100	4	
11.03.2019	8.9	0.03		100	4	
12.03.2019	8.8	0.02		100	4	

*About 4 to 10 mg/l of fluoride contaminated water was prepared synthetically using CSIR-IMMT laboratory tap water (groundwater source)

Table-2.2:

Performance evaluation of Fluoride removal using HIX-Nano 200 resin for dug well water collected in fluoride affected area Balsinghpur, Dist. Nayagarh Odisha

Date	Fluoride content, Before filtration mg/L	Fluoride content, After filtration mg/L	BIS (10500) Limit for Fluoride mg/l	Flow rate litre/hr	Flow time In Hour	Regeneration
14.03.2019	3.75	0.42	Acceptable limit – 1 Max. permissible limit – 1.5	100 litre	4	No regeneration done
15.03.2019	3.75	0.50		100 litre	4	
16.03.2019	3.75	0.51		100 litre	4	
18.03.2019	3.75	0.55		100 litre	4	
19.03.2019	3.75	0.56		100 litre	4	

Table-2.3: Key parameters of synthetic water on fluoride removal (before and after passing through resin) as per IS 10500:2012

PARAMETERS	28.02.2019		01.03.2019		04.03.2019		05.03.2019		06.03.2019		07.03.2019		11.03.2019		12.03.2019	
	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After	Before	After
pH	5.86	7.95	5.81	7.81	6.02	8.14	6.01	8.10	5.89	7.92	5.96	7.99	5.92	7.85	5.96	8.01
COLOR	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
TDS, mg/l	212	308	217	311	215	313	231	319	233	313	221	309	224	313	226	306
TSS, mg/l	2.64	0.15	3.62	0.26	4.52	0.18	3.62	0.15	2.58	0.14	6.24	0.18	3.94	0.22	1.15	0.07
Conductivity,µs/cm	424	617	434	623	431	626	463	639	466	627	443	618	448	627	453	612
Turbidity, NTU	0.36	0.10	0.26	0.12	0.42	0.13	0.52	0.12	0.14	0.02	0.25	0.06	0.29	0.07	0.36	0.07
Alkalinity, mg/l	6.0	18.0	6.0	18.0	6.0	20.0	6.0	20.0	6.0	18.0	6.0	18.0	6.0	18.0	6.0	20.0
Hardness, mg/l	22.0	6.0	24.0	6.0	22.0	5.0	24.0	6.0	22.0	6.0	22.0	6.0	24.0	6.0	24.0	6.0
Sulphates, mg/l	3.26	2.75	3.16	2.86	3.34	2.95	3.39	2.86	3.28	2.36	3.19	2.59	3.65	2.84	3.74	3.06
Chloride, mg/l	24.0	64.0	24.0	63.0	24.0	62.0	24.0	66.0	25.0	66.0	25.0	64.0	24.0	64.0	24.0	63.0
Carbonate, mg/l	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Calcium, mg/l	5.2	0	5.2	0	4.8	0	4.8	0	4.8	0	4.8	0	5.2	0	5.2	0
Magnesium, mg/l	2.19	1.46	2.68	1.46	2.44	1.22	2.93	1.46	2.44	1.46	2.44	1.46	2.68	1.46	2.68	1.46
Sodium, mg/l	26.59	47.56	24.62	43.26	24.51	44.29	23.64	42.15	22.68	42.58	25.64	47.63	24.75	45.28	23.64	44.15
Potassium, mg/l	0.09	0.03	0.12	0.06	0.18	0.09	0.15	0.06	0.12	0.05	0.14	0.05	0.09	0.02	0.13	0.02

Table-2.4: Key parameters on fluoride removal for fluoride contaminated Dug well water, Balasinghpur, Nayagarh Dist. (before and after passing through resin media **HIX-Nano 200**) as per IS: 10500:2012

Parameters	Balasinghpur Raw Water 14.03.2019	Balasinghpur Treated Water 16.03.2019	Balasinghpur Treated Water 19.03.2019
Fluoride, mg/l	3.75	0.51	0.55
pH	7.87	6.27	6.52
TDS, mg/l	5740	5900	5920
TSS, mg/l	48.96	5.61	4.85
Conductivity, μ S/cm	11470	11780	11840
Turbidity, ntu	16.4	1.69	1.52
Alkalinity, mg/l	322.0	60.0	62.0
Hardness, mg/l	742.6	12.01	14.01
Sulphates, mg/l	237.6	2.68	3.61
Chloride, mg/l	1064.6	2409.2	2399.2
Carbonate, mg/l	Nil	Nil	Nil
Calcium, mg/l	173.1	1.6	2.4
Magnesium, mg/l	75.3	1.9	1.4
Sodium, mg/l	545.8	680.5	684.7
Potassium, mg/l	12.6	0.05	0.04

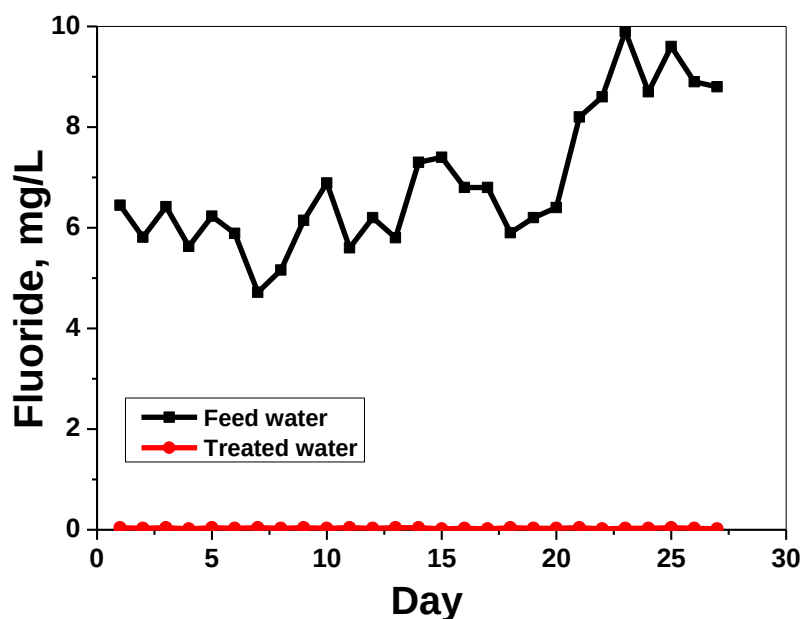


Figure 2.1: Removal of Fluoride in synthetic water by **HIX-Nano 200** resin of WIST Water Solutions Pvt Ltd in a packed bed column (**Conditions:** Flow rate,100 L/h; run time per day, 4 hour)

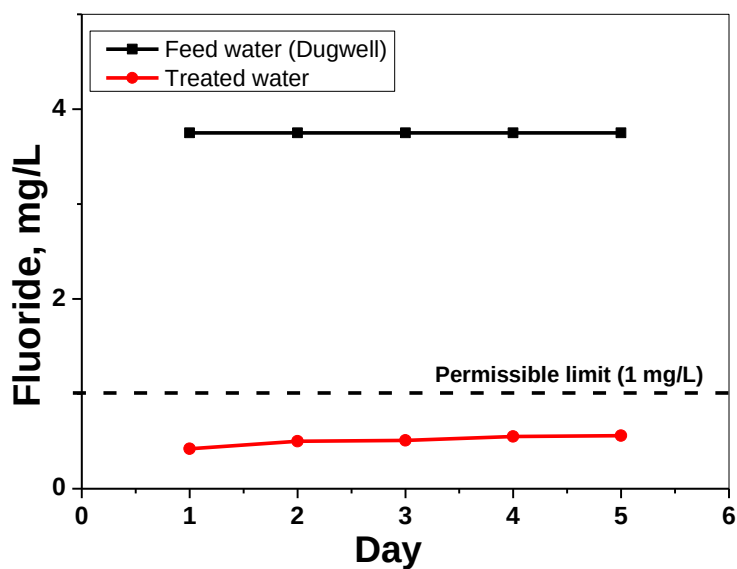


Figure-2.2: Removal of Fluoride from contaminated water collected from a Dug-well, Balsinghpur, Nayagarh Dist, Odisha by **HIX-Nano 200** resin of WIST Water Solutions Pvt Ltd (**Conditions:** Flow rate,100 L/h; run time per day, 4 hour).

2.4. Conclusion:

From the study the following conclusion may be drawn.

1. The **HIX-Nano 200** resin and the system set-up provided by **WIST WATER SOLUTIONS PVT LTD** have been tested for removal of fluoride from water containing fluoride up to 9.9 mg/l.
2. The removal efficiency of the fluoride removal media (HIX-Nano 200) has been tested using synthetically prepared fluoride contaminated water (max fluoride- 9.9 mg/l) and also naturally occurring fluoride contaminated water (fluoride – 3.75 mg/l).
3. **HIX-Nano 200** is found to remove fluoride satisfactorily within the limit of test conditions.
4. Periodic monitoring of fluoride removal plant is required and regeneration/change of resin media must be done when required.
5. At the time of installation the fluoride removal plant, fresh **HIX-Nano 200** resin must be used and washing may be done if required.
6. The given parameters of water in the report has been done as per BIS standard IS 10500:2012

N: B-This test report is the property of CSIR-IMMT and only applicable to WIST WATER SOLUTIONS PVT LTD. This report cannot be shared/sub-contracted with any other parties/firms/person without prior permission of CSIR-IMMT



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No. : 1129/E & S/SSP- 347 /June/2019

To Whom It May Concern

This is to certify that CSIR-IMMT Bhubaneswar tested hybrid ion exchange nanotechnology media **HIX-Nano 200** of **WIST WATER SOLUTIONS PVT. LTD.**(brand name “drinkwell”), 78 Biren Roy Road West, Kolkata 700061, for Fluoride removal at CSIR-IMMT, Bhubaneswar.

Fluoride removal column set-up filled with media **HIX-Nano 200** of **WIST WATER SOLUTIONS PVT LTD**, was tested using feed water contaminated with different level of fluoride up to about 10 mg/l. The media HIX-Nano 200 was found to remove fluoride efficiently within the permissible limit as per BIS 10500-2012

Fluoride removal efficiency was tested in lab scale in both synthetically prepared fluoride contaminated water and naturally occurring fluoride contaminated water.

N: B-This is only applicable to WIST WATER SOLUTIONS PVT LTD

(Signature) 19/06/19

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