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Improvement of water quality of Adalatganj Area, Patna by Vermifiltration

• **Shabistan Jabin** • **Sristi Sonam** • **Sweta Kumari**
• **Sister M. Stuti A.C.**

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Corresponding Author : Sister M. Stuti A.C.

Abstract : *Water is one of the precious natural resources present on the earth and it is vital for the survival of living being . The present study mainly focus on the groundwater quality. Removal of various metals is one of the important and widely investigated area of research. In our present study, a survey was carried out in the study area, Adalatganj, Patna regarding the quality of water used .the efficiency of earthworm Eisenia fetida in bio-remediation of iron contaminated water has been investigated. The groundwater samples of Adalatganj were tested and analysis of Fe concentration in Atomic Absorption Spectrophotometer showed that there was significant decrease in the concentration of iron when treated in both the conventional method (without worms)and through vermibed with earthworms Eisenia fetida as compared to the concentration of Fe in raw groundwater sample of Adalatganj in which the concentration of Fe was high. The test for bioaccumulation showed that the tissues of worms accumulated iron in higher concentration. The result indicated that the earthworms can accumulate Fe in their body tissues and bioremediate iron contaminated water.*

Keywords: *Iron, Bioremediation, Earthworms, Eisenia fetida.*

Shabistan Jabin
B.Sc. III year, Zoology (Hons.),
Session : 2016-2019, Patna Women's College,
Patna University, Patna, Bihar, India

Sristi Sonam
B.Sc. III year, Zoology (Hons.),
Session : 2016-2019, Patna Women's College,
Patna University, Patna, Bihar, India

Sweta Kumari
B.Sc. III year, Zoology (Hons.),
Session : 2016-2019, Patna Women's College,
Patna University, Patna, Bihar, India

Sister M. Stuti A.C.
Assistant Professor, Department of Zoology,
Patna Women's College, Bailey Road,
Patna–800 001, Bihar, India
E-mail : mstuti07@gmail.com

Introduction :

Water is one of the earth's most important resources and its quality is totally dependent on geological environment, recovery, utilization as per need and human activities like domestic, industrial or commercial, mining operations, agricultural etc. In short freshwater is directly linked with human welfare as it is vital concern for human kind. But today most of the surface and subsurface water bodies are unfortunately under the environment stress. There is a high risk of contamination of water by percolation, surface runoff. Human health is threatened by most of the agricultural development activities (Phadatare and Gawande, 2016).

Rapid urbanization, especially in developing countries like India, has affected the availability and quality of groundwater due to its overexploitation and improper waste disposal, especially in urban areas (Sukumaran et al., 2015). A serious groundwater crisis prevails currently in India due to excessive overdraft and groundwater contamination covering nearly 60% of all districts in India and posing a risk to drinking water security of the population, as more than 80% of India's drinking water needs are serviced by groundwater resources.

Removal of various metals is one of the important and widely investigated areas of research. (Kulkarni et al, 2014; Mudgal et al, 2010). The organic pollutants and heavy metals affect adversely man and environment.(Kulkarni et al., 2014).Their removal can be carried out by biological methods like activated sludge methods and trickling filters (Ahmad et al., 2008). Adsorption is most widely used methods practically and in research also (Kulkarni and Kaware, 2013; Trivunac and Stevanovic et al., 2012).

If groundwater sources are to be suggested for various uses, its quality should be assessed (Abbulu and Rao , 2013).

The use of earthworms for water bioremediation is a biological method, so that the pollutant concentrations in the water are reduced through bioaccumulation mechanisms in the body of the earthworms (Matscheko et al., 2002; Slizovskiy and Kelsey, 2010). These organisms can accumulate high concentration of heavy metals in their bodies (Li et al., 2010).

Vermifiltration Technology (VFT) is the most cost-effective and eco-friendly. Introduction of earthworms into the filtration system, with suitable bedding materials to breakdown organic pollutants is called vermifiltration (Tomar and Suthar, 2011; Arora et al ., 2016).Vermifiltration technology, which uses earthworms as the means of aerobically treating water, is increasingly becoming an environmentally friendly water treatment technique (Manyuchi et al., 2013).

The slum area of Adalatganj, Patna, Bihar has filthy groundwater which leads to various problems in health, skin, teeth etc.This project is an extention work from campus to community in which the water analysis of the area is done and awareness will be given to the people living in Adalatganj regarding the usage of water. Therefore the present study is undertaken to assess the efficiency of earthworm to remove heavy metal iron and improve the water quality of Adalatganj area through vermifiltration.

The study area Adalatganj lies at 25°36'31"N 85°7'56" E in Patna in the state of Bihar India. For this project survey of 100 families residing in the Adalatganj area was done to study of quantity and quality of water used by the people. Some demographic attribute used in survey were as follows:-Water intake, amount of water used daily for various purposes, modes of water supply, toilet facility, types of diseases or ailment.

Materials and Methods :

Conventional method: The containers were kept on a stand one below the other the topmost container of 10 liters , 'A', was used to fill the groundwater sample .The system consisted of simple 0.3 cm pipes with holes for trickling water that allowed uniform distribution of groundwater on different layers in container 'B'. the container 'B' consisted layers of big gravels (size:3-4 cm),followed by small-sized gravels(size:1-2 cm) ,which were kept in two consecutive layers followed by sand and activated charcoal and each layer was of 12 cm height (Sinha et al.,2008) (Fig.1)

Vermifiltration bed: The same set-up was made as with the conventional method .On the topmost layer, shredded filter paper was used as a feed material and 250 earthworms *Eisenia Fetida* were introduced (Sinha et al.,2008) (Fig.2).The worms were given around 5 days settling time in the shredded filter paper to acclimatize in the new

environment.24 hours retention period was provided to the earthworms to perform their action (Fig.2 and Fig.4). In both beds 10 liters of groundwater sample was allowed to pass from 'A' to 'B' and then water was collected from container 'C'.

Another set of experiments were set up for the conventional method and vermifiltration bed. But here, instead of activated charcoal sawdust was used (Fig.3 and Fig.4).

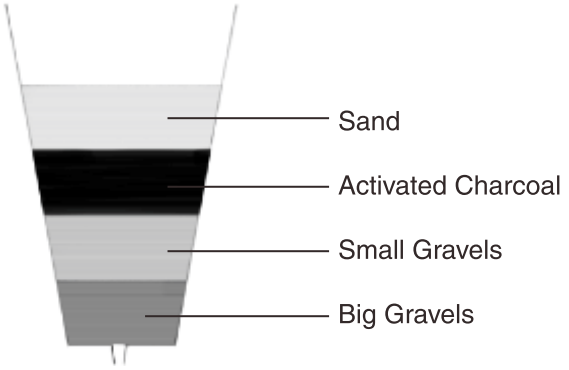

Fig.1. First experimental set-up of Conventional method (with activated charcoal)

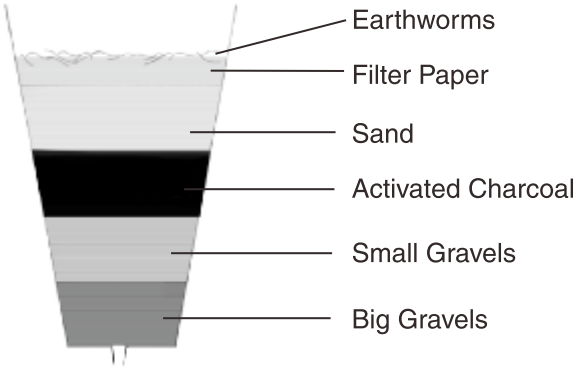

Fig. 2. First experimental set-up of Vermifiltration bed (with activated charcoal)

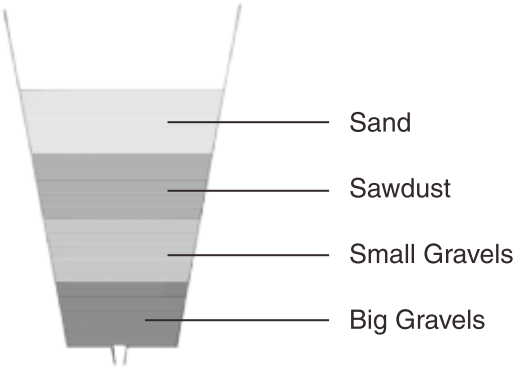

Fig. 3. Second experimental set-up of Conventional method (with sawdust)

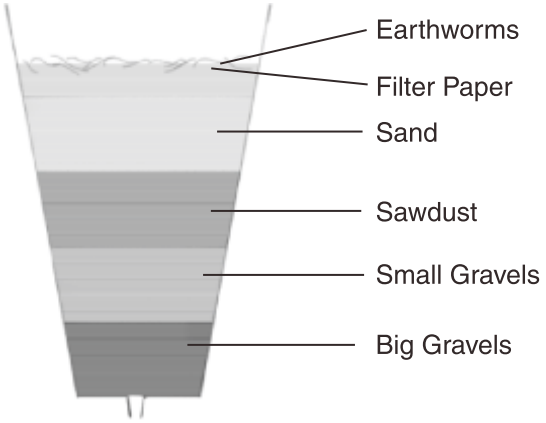

Fig. 4. Second experimental set-up of Vermifiltration bed (with sawdust)

The test was analyzed for its pH . Iron content in µg/L was analyzed using AAS (Atomic Absorption Spectrophotometer) Savant AA-AAS,GBC, Australia.

Groundwater sample was collected from Adalatgunj, Patna, Bihar. This groundwater sample was passed through the set-up completely in 24 hours. A total of 3 series were repeated in each of the set-ups.

Estimation of Fe in water: Standard solutions of 1 ppm, 2 ppm, 4 ppm and 8 ppm concentrations were prepared in a 100 ml Volumetric flask and the equipment was calibrated.Then samples of control 'C' and test 'T' were collected at intervals of 24 hours for iron analysis .The samples were analyzed using Savant AA- Atomic Absorption Spectrophotometer (AAS).The sample is injected through the nozzle and the acetylene gas burns the sample and generates colours of different intensities. The detector reads the color intensity and displays the result in µg/L. Both control and tested earthworms were collected and their tissues were analyzed to test for the bioaccumulation of Fe in their tissues.

Preparation of Earthworm powder: Earthworms were washed and kept on moist filter paper in a petridish and were left in the BOD Incubator for 24 hours at 5°C to flush out the matter

from the gut .The earthworms were then kept in Hot Air Oven for 2-3 hours at 150°C. The dried body tissue of earthworms were grinded with mortar and pestle to convert them into powder which were then digested.

Acid Digestion of Earthworm Powder: To the sample,10 ml of freshly prepared acid mixture of 65% HNO_3 and 37% of HCl was added .Then, the mixture was boiled gently over water bath (95 C) for 4-5 hours or until the sample had completely dissolved) (Ang and Lee,2005).

Stastical Analysis: The results are presented as mean ± SE. Total variation present in a set of data through one way Analysis of Variance (ANOVA) and t-test. The level of significance was taken as $p<0.05$.

Results and Discussion :

In our survey, we found that the area has total four hand pumps out of which only one is functional and the rest three are non-functional. The area also has supply water but it is not sufficient to support the families living in the area as it is densely populated. Hence, they are forced to use the hand pump water for daily use.

According to the survey most of the families are not economically prosperous so they cannot afford expensive water purifiers.

1. WATER INTAKE BY PEOPLE OF ADALATGANJ

NO. OF GLASSES PER DAY	NO. OF INDIVIDUALS	PERCENTAGE SHARE
More than 10	22	22%
9-7	54	54%
6-4	16	16%
Less than 4	8	8%

Source: Based on sample survey, 2018.

2. AMOUNT OF WATER USED DAILY FOR VARIOUS PURPOSE (WASHING,BATHING,COOKING)

AMOUNT OF WATER USED	NO. OF FAMILIES	PERCENTAGE SHARE
More than 100 liters	13	13%
100-80 liters	66	66%
80-60 liters	15	15%
60-40 liters	4	4%
Less than 40 liters	2	2%

Source: Based on sample survey, 2018.

3. MODES OF WATER SUPPLY

MODES OF WATER SUPPLY	NO. OF HOUSE	PERCENTAGE SHARE
Community hand pump	42	42%
Tap	10	10%
Boring	38	38%
Supply	10	10%
Wells	0	0%
Other	0	0%

Source: Based on sample survey, 2018.

4. TOILET FACILITY

TOILET FACILITY	NO. OF FAMILIES	PERCENTAGE SHARE
Toilet facility at home	22	22%
Public toilet	54	54%
Field	34	34%

Source: Based on sample survey, 2018.

5. HEALTH RELATED PROBLEMS

HEALTH RELATED PROBLEMS	NO. OF INDIVIDUALS	PERCENTAGE
Gastric problems	42	42%
Constipation	57	57%
Diarrhoea	4	4%
Skin disease	46	46%
Yellowing of teeth	67	67%

Source: Based on sample survey, 2018.

In the present study, it was observed that the pH, turbidity and electrical conductivity of water sample from Adalatganj decreased after its treatment with conventional method (without worms) and when treated with earthworm *Eisenia fetida* . The results were significant (Table 1). It was also noticed that there was a slight change in the body colour of earthworms *Eisenia fetid* when they were treated with groundwater of Adalatganj.

Table 1. Values of some Physical parameters of the groundwater

Physical parameters	Untreated (Groundwater sample)	Treated water (Activated charcoal)	Treated water (Activated charcoal +	Treated water (Sawdust) worms)	Treated water (Sawdust + worms)
pH	7.03±0.003	7.00±0.008	7.00±0.003	7.02±0.006	7.00±0.006
Turbidity (NTU)	9.04±0.14	0.55±0.11	0.77±0.11	3.72±0.7	1.62±0.2
Electrical Conductivity (µS/cm)	1202±0.88	925.6±0.42	907.6±0.35	1131±0.86	914.6±0.61

Values are Mean±SE(n=3)

First Experimental Setup (with activated charcoal):

Table 2. Changes in the concentration of Fe (µg/L) in the experimental set-up (with activated charcoal)

S. No.	Ground water (µg/L) (untreated)	Control 'C' (µg/L) (without worms)	Test 'T' (µg/L) (with worms)
1.	1.183±0.001	0.147±0.04*	0.066±0.009*
2.	1.180±0.001	0.144±0.04*	0.039±0.009*
3.	1.183±0.001	0.017±0.04*	0.034±0.009*

Values are Mean±SE(n=3). *Significant at P<0.05

Table 3. Bioaccumulation of Fe (µg/L) in the tissues of *Eisenia fetida* (with activated charcoal)

S.No.	Control *Eisenia fetida* (C.*Ef.*) (µg/L)	Test *Eisenia fetida* (T.*Ef.*) (µg/L)
1.	0.331±0.0003*	2.154±0.001*
2.	0.331±0.0003*	2.155±0.001*
3.	0.330±0.0003*	2.157±0.001*

Values are Mean±SE(n=3) *Significant at P<0.05

In the present study, it was observed that there was decrease in concentration of Fe (µg/L) in the groundwater sample after it was treated with the conventional method (without worms and with worms *Eisenia fetida*).

The earthworm *Eisenia fetida* decreased the iron concentration to a very significant level when groundwater sample was treated by the vermifiltration method (with worms). This was probably due to the introduction of the earthworms since they accumulate iron in their body tissues (Table 2).

Table 2 and Fig. 1 show that there was decrease in the concentration of Fe in the groundwater sample after treatment with the conventional method (without worms) which were 87.6%, 87.8% and 98.6% at the end of 1st ,2nd and 3rd series respectively. The results were significant at $p<0.05$ when compared to groundwater sample.

Table 2 and Fig. 1 also show that there was decrease in the concentration of Fe in the groundwater sample after treatment with earthworms (*Eisenia fetida*) which were 94.4 %, 96.7 % and 97.1 %at the end of 1st , 2nd and 3rd series respectively. Thus, the results were significant at $p<0.05$ when compared to ground water sample.

Table 3 and Fig. 2 show that the accumulation of Fe in the tissues of earthworm bodies was 84.64%, 84.65% and 84.7% higher when compared to the untreated or controlled earthworms at the end of 1st , 2nd and 3rd series respectively and the result was significant at $p<0.05$.

Change in the concentration of Fe (µg/L) in the ground water sample after its treatment with the conventional method (with charcoal) and bioaccumulation of Fe in the tissues of earthworm *Eisenia fetida* are shown through the graph in Figure 1 and Figure 2 respectively.

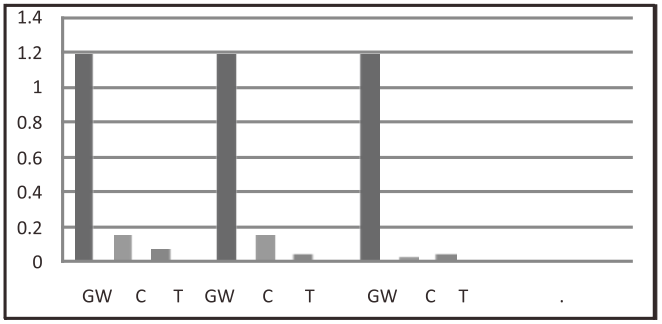

Fig 1. Change in the concentration of Fe (µg/L) in the experimental set-up (with activated charcoal)

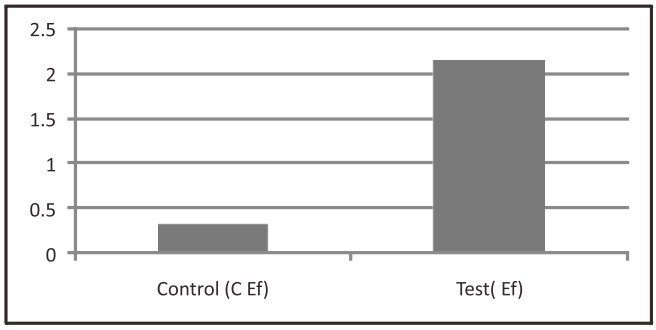

Fig. 2. Bioaccumulation of Fe (µg/L) in the tissues of *Eisenia fetida* (with activated charcoal)

Second experimental set-up (with sawdust):

Table 4. Change in concentration of Fe (µg/L) in the experimental set-up (with sawdust)

S. No.	Groundwater (µg/L) (untreated)	Control 'C' (µg/L) (without worms)	Test 'T' (µg/L) (with worms)
1.	1.183±0.001	0.383±0.09*	0.374±0.10*
2.	1.180±0.001	0.175±0.09*	0.115±0.10*
3.	1.183±0.001	0.040±0.09*	0.032±0.10*

Values are Mean±SE(n=3) *Significant at $P<0.05$

Table 5. Bioaccumulation of Fe (µg/L) in the tissues of *Eisenia fetida* (with sawdust)

S.No.	Control *Eisenia fetida* (C.*Ef.*) (µg/L)	Test 'T' *Eisenia fetida* (T.*Ef.*) (µg/L)
1.	0.331±0.0003*	1.712±0.0012*
2.	0.331±0.0003*	1.715±0.0012*
3.	0.330±0.0003*	1.716±0.0012*

Values are Mean±SE(n=3) *Significant at $P<0.05$

In the second experimental set-up there was a decrease in the concentration of Fe when it was treated with conventional method (without worms) and when treated with earthworm *Eisenia fetida*. This was done in comparison to the presence of Fe in groundwater sample of Adalatganj.

Table 4. and Fig. 3. Shows that there was a decrease in the concentration of Fe in the groundwater sample after its treatment with the conventional method (without worms) which were 67.6 % , 85.2 % and 96.62% at the end of 1st, 2nd and 3rd series respectively. The results were significant at $p<0.05$ when compared to the groundwater sample.

Table 4. and Fig. 3. Shows that there was a decrease in the concentration of Fe in the groundwater sample after its treatment with the conventional method (with worms) which were 68.4%, 90.26% and 97.3% at the end of 1st, 2nd and 3rd series respectively. However results were significant at <0.05 when compared to the groundwater sample.

Table 5 and Fig. 4 shows that the accumulation of Fe in the tissues of earthworm bodies was 80.67%, 80.7% and 80.77% higher when compared to the untreated or controlled earthworms at the end of 1st , 2nd and 3rd series respectively which was significant at $p<0.05$.

The variation in concentration of Fe in the ground water sample after its treatment with the conventional method (with charcoal) and bioaccumulation of Fe in the tissues of earthworm *Eisenia fetida* are shown through the graph in Table 3 and Fig. 4 respectively.

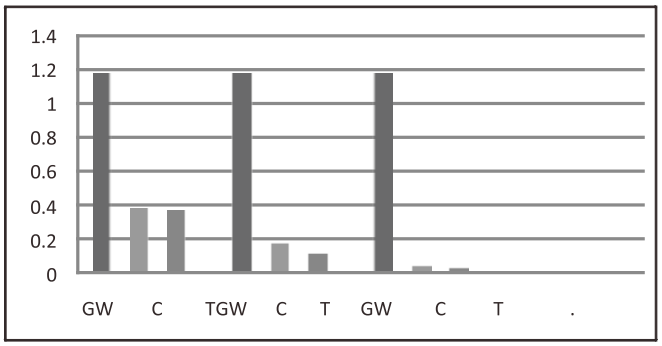

Fig 3. Change in the concentration of Fe (µg/L) in the experimental set-up (with sawdust)

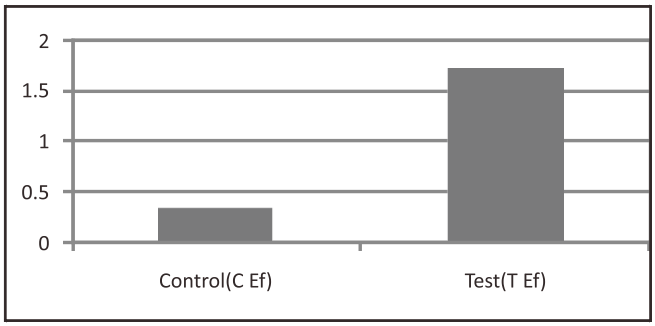

Fig. 4 Bioaccumulation of Fe (µg/L) in the tissues of *Eisenia fetida* (with sawdust)

Presence of Other Heavy Metals

Tests for the presence of other heavy metals like lead(Pb) and cadmium(Cd) was also done.

Table 6.Concentration of other heavy metals in the groundwater

S. No.	Conc. In Untreated Groundwater (µg/L)	
	Cd	Pb
1.	0.003±0.0006	00
2.	0.003±0.0006	00
3.	0.001±0.0006	00

Values are Mean±SE (n=3)

Iron particles (consisting of Fe (III) oxides and hydroxides) in water supply cause various aesthetic and operational problems including bad taste, discoloration, deposition and resuspension in the distribution system (Prince et al, 2003).

In our study, the groundwater sample collected from the Adalatganj area showed some signs like discoloration, bad taste and bad odour. Hence, it was suspected to contain iron.

Tests for other heavy metals like lead (Pb) was done but it was not detected and Cadmium (Cd) was present in negligible amount (0.003µg/L). Hence, the main focus of the study was iron.

Vermifiltration method of water treatment is low energy dependent and has distinct advantage over all the conventional, biological waste water system which are highly energy intensive, costly to install and operate (Sinha et al, 2008).

Earthworms can bio-accumulate and bio-transfer many chemical contaminants including heavy metals and organic pollutants in soil and clean up the contaminated lands. Their body works as a 'biofiler' and they can 'purify', 'disinfect' and 'detoxify' municipal and several industrial wastes (Morgan and Morgan, 1999).

There was decrease in the concentration of iron in water treated by earthworms as compared to the conventional method (without earthworms) (Table 2 and 3). The present findings clearly show that earthworms can accumulate the heavy metals like iron in their body tissues.

pH usually has direct effects on biotic environment. For satisfactory water disinfection and clarification at all stages the control of pH is necessary. The pH should preferably be less than 8. (Sukumaran et al, 2015) pH of treated water was found within the range of Indian standards (7.0 – 8.0).

The presence of faecal and total coliforms in water make it unfit for drinking (Sukumaran et al, 2015) In our study, the coliform test was performed but the test was negative.

Conclusion:

In our study it was concluded that the groundwater of Adalatganj area , Patna contains iron in large amount which makes it unfit for direct consumption .

In conventional method, the setup containing activated charcoal filtered water from the groundwater more efficiently as compared to the setup containing sawdust because due to sawdust there was discoloration and foul smell in the filtered water.

In the setup containing earthworms there was further decrease in iron content as earthworm can accumulate heavy metals in their body tissues.

Vermifiltration technology is eco-friendly and inexpensive as compared to other complex and costly methods used for removal of heavy metals.

Since the Fe contamination may be due to geogenic. Various awareness programme regarding nutritive food supplement which can reduce the effect of Fe accumulation in the body will be done.

We will make the people aware to consume vitamin C-rich foods such as amla, guava, some lime juice, mustard, leafy vegetables and make them aware to avoid coffee, tea or milk near meals as well as food rich in iron.

In the survey conducted in the area of Adalatganj it was found that due to the consumption of iron rich water yellowing of teeth, itching and scars on skin and most of them had gastric problems.

Excess of iron may cause dental diseases, gastrointestinal problems, mental retardation and neuro-problems among humans.

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