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STUDY OF IRON CONTENT IN GROUND WATER OF BANGLADESH

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ABSTRACT : This study is an attempt to assess the concentration of iron in ground water of deep tubewells of Bangladesh and its suitability mainly for drinking. Water samples from about 1000 deep tubewells of the 56 administrative districts out of 64 administrative districts, which cover about 86% of total area of Bangladesh were analysed. In this study, experimental results have been compared with the Bangladesh water quality standard for drinking. The analysis shows that about 41% and 22.5% of the studied area exceed iron concentration of 1.0 mg/l and 5.0 mg/l respectively. Attempt has also been taken to correlated between iron content in ground water and aquifer materials characteristics. Iron content in ground water is greatly influenced by the iron content in aquifer material.

KEY WORDS : Groundwater, Deep Tubewell, Correlation, Iron, Aquifer material.

INTRODUCTION

Water is a basic necessity of man along with food and air, the importance of supplying hygienic potable /fresh water can hardly be over stressed. The impact of many diseases affecting mankind can be drastically reduced if fresh hygienic water is provided for drinking. Bangladesh is mainly dependent on ground water for drinking water supplies. Ground water quality of any area is of great important for human being. The ground waters irrespective of their source of origin contain mineral salts and other chemical compounds such as iron, manganese, nitrate, fluoride, calcium, sodium etc. The kind and concentration of constituents depend upon various geological, geo-hydrological and physical factors of the aquifers (Huda,1995). The quality and composition of the dissolved mineral in natural water depend upon the type of rock or soil with which it has been in contact or through which it has percolated, and the duration it has been in contact with these rocks. The quality of ground also varies form season to season. Iron occurs in underground water as a soluble (ferrous) form and it becomes as an insoluble (ferric) form when it comes in contact with air. Presence of iron in water changes the characteristics of fresh water,

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alters colour of water as well as taste of water. Iron contained water makes the teeth and nail black and weak, stickiness of hair and roughness of skin. Soap also don't response well if iron is present in water. Iron problem is acute in various places in ground water of Bangladesh. but there has been no thorough investigation on the iron content in ground water of deep tubewells of Bangladesh. The present investigation was therefore carried out to study the iron content in ground water of Bangladesh, suitability of ground water for drinking and also to establish a correlation between iron content in ground water and aquifer material characteristics.

ANALYSIS OF THE IRON CONTENT IN GROUND WATER OF BANGLADESH

Data collection: The data considered here were collected from the various agencies involved in the work of underground water. Mainly these data were collected from Environmental Engineering Laboratory, Bangladesh University of Engineering & Technology (BUET), Dhaka and Bangladesh water development Board (Ground Water Circle), Dhaka. These data were compiled according to the administrative districts of Bangladesh. Maximum 50 numbers of water quality data have been found in Chittagong districts and minimum 4 numbers of water quality data have been found in Shariatpur, Habiganj, & Chandpur districts. Location of that collected samples have been shown in figure 1. In this analysis, iron content in ground water has been compared with the Bangladesh water quality standard for drinking.

Results and discussions : Ground water quality data of about 1000 deep tubewell samples from about 124000 sq.km. area which covers 56 administrative districts of Bangladesh out of 144000 sq.km. area of 64 administrative districts were analysed for drinking purposes. Inadequate information are available of about 20000 sq.km. area (rest 8 districts) of Bangladesh. Allowable limit of iron in water for drinking in Bangladesh is 0.3-1.0 mg/l. The limit may be considered upto 5.0 mg/l having no alternative suitable drinking water sources (DOE, 1991). Two analysis have been performed with the help of GIS, having iron concentration exceeding 1.0 mg/l and exceeding 5.0 mg/l are shown in figure-2 & figure-3 respectively. From figure-2, it is observed that there are iron problem almost all areas of Bangladesh. Ground water of about 51000 sq. k. (41%) of the studied area contain more than 1.0 mg/l of iron. Whereas about 28000 sq. km. (22.5%) of the studied area contain iron more than 5.0 mg/l. Iron problem is acute in ground water in the districts of Manikganj, Gopalganj, Norshingdi, Narayanganj, Rajshahi, Bagerhat, Sylhet, Sunamganj, Noakhali, Khulna and Kurigram. The people in the problem areas use tubewell water having 4.0 mg/l of iron without much hesitation (Ahmed, 1981) but water of such quality is not acceptable in other region of the country. The major causes of the non-usage of water with excessive iron are bad taste and odour; stickiness of hair and

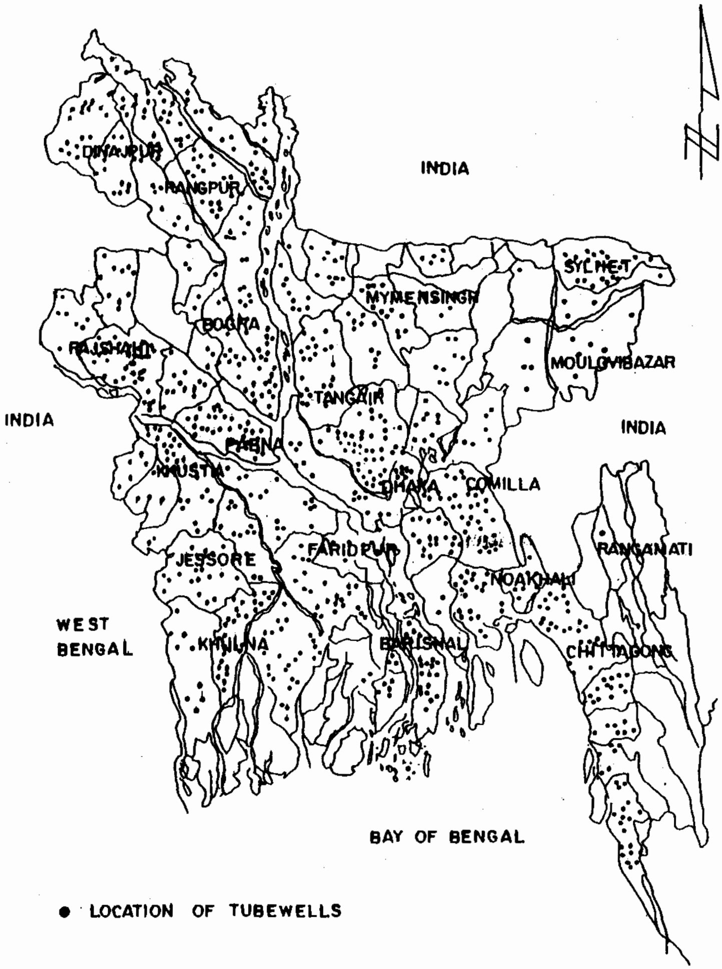

Fig 1. Location of the observed deep tubewells of Bangladesh

roughness of skin and also it makes the teeth and nail black and weak Iron removal plant is essential for the above mentioned excessive iron content areas of Bangladesh. Aeration, coagulation/flocculation, sedimentation and filtration is required for a large scale treatment process. A community type iron removal plant attached to each tubewell in these iron problem areas may be installed to make the water acceptable for domestic uses for a small scale treatment process. From figure-4, it is observed that iron content in ground water may increase or decrease with the increasing depth of the aquifers. It is clear that iron content in ground water depends on various geological, geohydrological and physical factors of the aquifers.

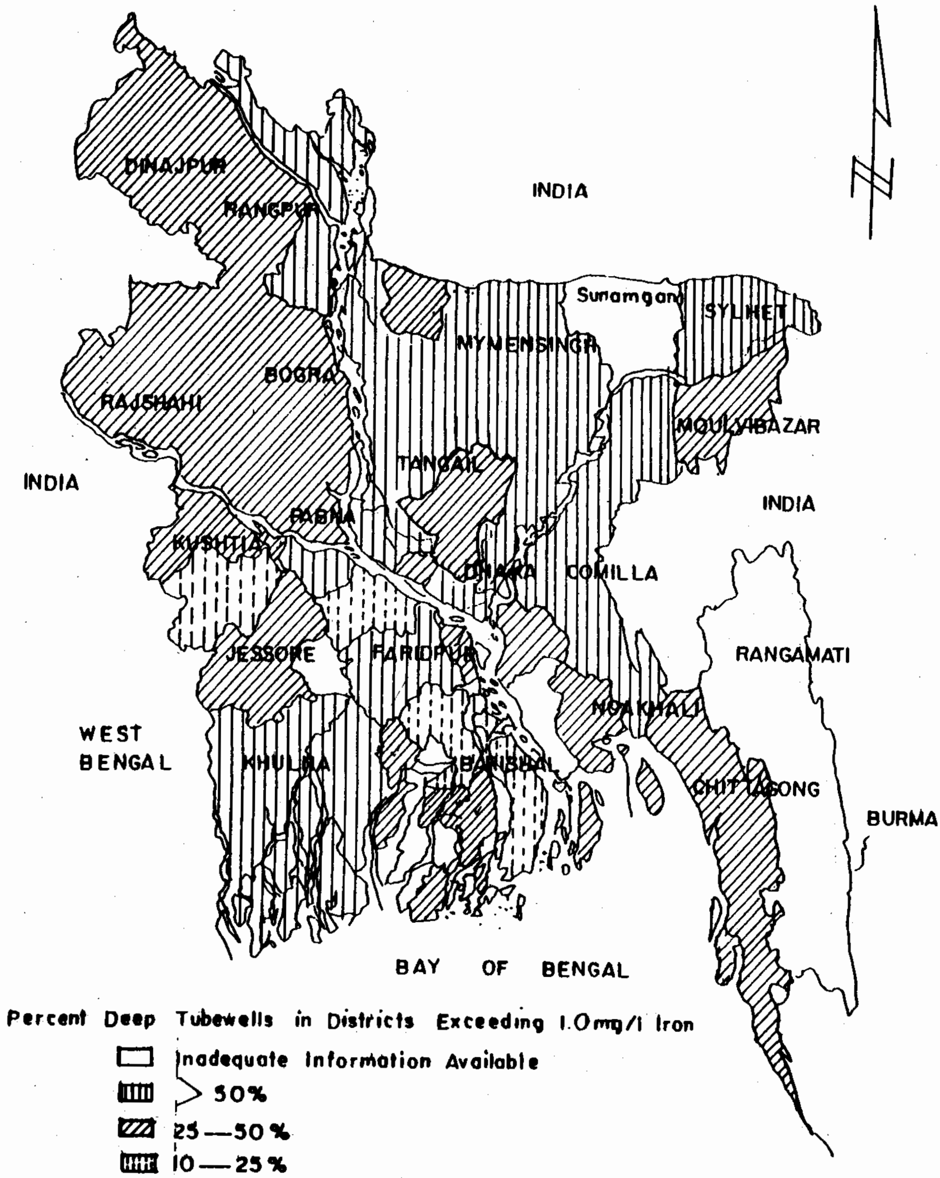

Fig 2. Iron content is deep tubewell water of Bangladesh (Iron>1.0mg/ 1)

CORRELATION BETWEEN IRON CONTENT IN GROUND WATER AND AQUIFER MATERIAL CHARACTERISTICS

Sample Collection : Shallow aquifer ground water samples and shallow aquifer material samples were collected by wash boring at 29

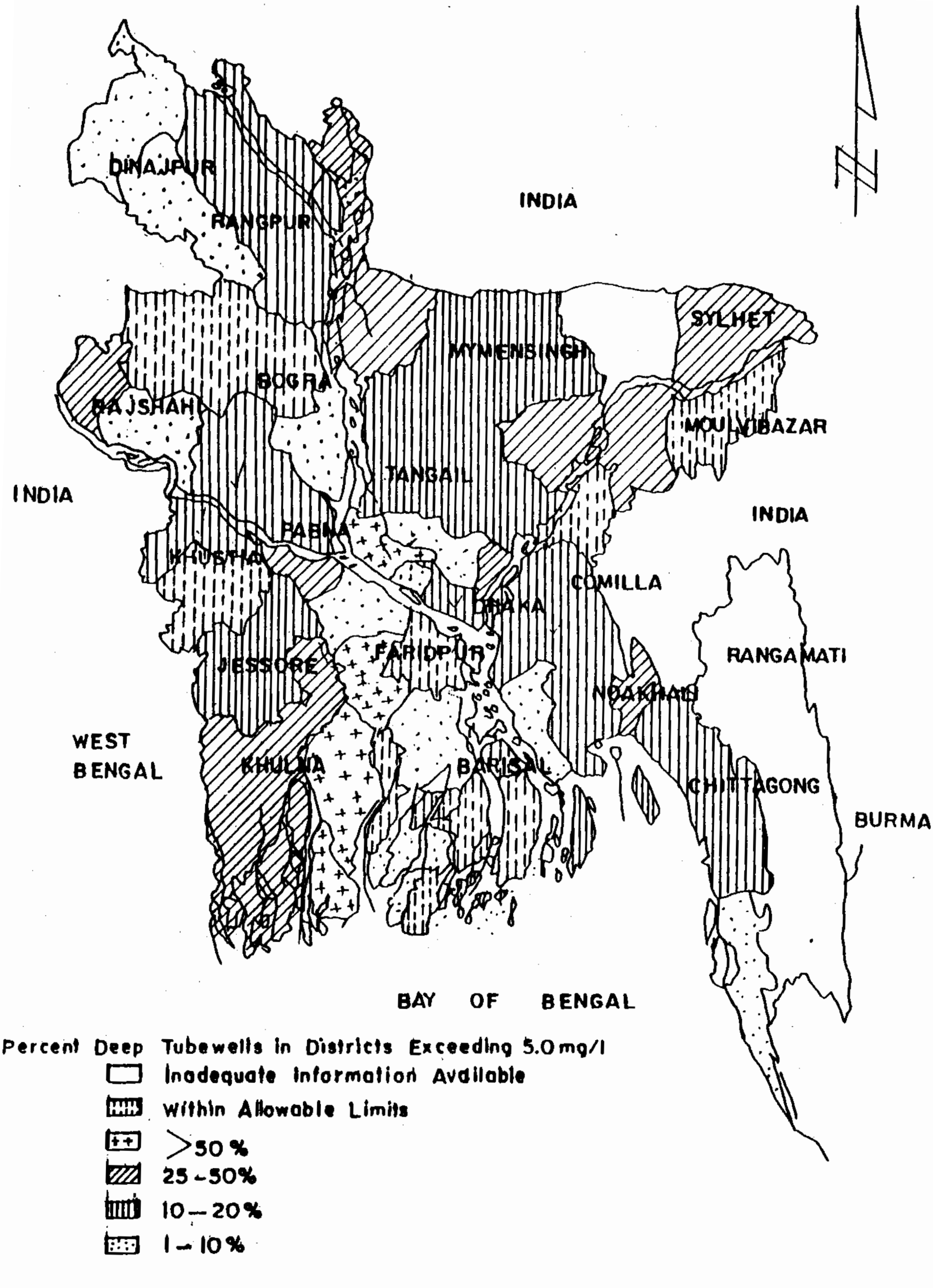

Fig 3. Iron content is deep tubewell water of Bangladesh (Iron>5.0mg/1)

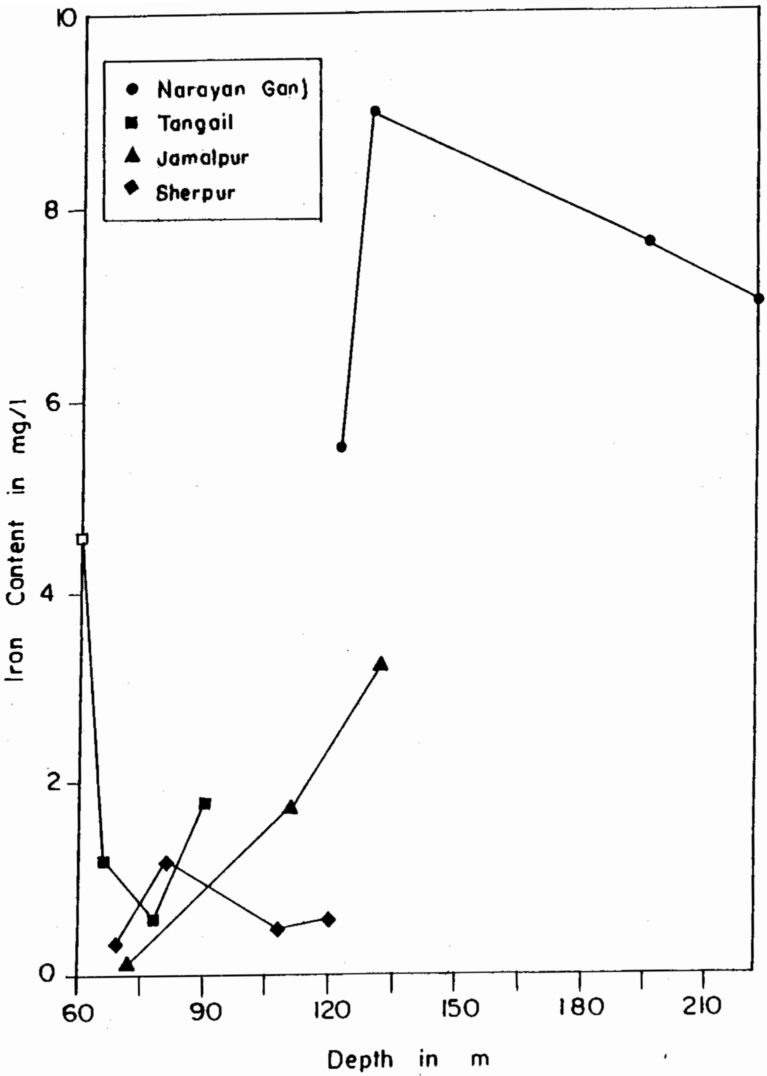

Fig 4. Variation of Iron Content in Ground Water with Depth

places of Rajshahi districts and 2 places of Dhaka districts were collected form environmental & Gotechnical engineering laboratory, BUET, Dhaka. It has not possible to collect aquifer material samples as undisturbed condition due to wash boring. It might be some variation between experimental results and actual condition due to said reason.

Experimental Technique : Measurement of Iron content in ground water samples and iron content in aquifer material samples were performed according to standard procedure and determination of effective size of aquifer material samples were performed according to ASTM.

RESULTS AND DISCUSSIONS

A regression analysis performed on the iron content in ground water (I_W) and the iron content in aquifer material (I_S), yields a relationship between Iw and Is as :

$$I_W = 0.04166 * (I_S)^{0.75413} \quad (1)$$

From the regression analysis, a correlation coefficient of 0.77 are found, using logarithmic scale for both the parameters. This regression analysis between I_W and Is leads to a very good positive corelation. If iron content in aquifer materials increases then iron content in ground water will also increases and vise-versa.

Two properties of an aquifer materials related to its storage function are its porosity and specific yield. Shape, size and packing of the grains affect the porosity of granular material. On the other hand, specific yield depends upon grain size, shape and distribution of pores and compaction of the aquifer formation. For this reason, grain size of an aquifer material is an important factor, which may be influenced on the iron content in ground water.

A regression analysis performed on the iron content in ground water (I_W) and effective size of aquifer material (d), using logarithmic scale for both parameters. Effective size of aquifer material (d) is considered as the opening size of 10% finer soil samples. A correlation coefficient of 0.46 are found form the analysis, using linear scale for both the parameters. This regression analysis between Iw and d leads to a weak positive correlation. If effective size of aquifer material increase then iron content in ground water will increases and vise-versa.

Granular aquifer material (Sand) has medium porosity, and higher specific yield than finer aquifer material (Silt, Clay). The specific yield of clayey particles tends to zero. Moreover, there is a strong water bound compression layer exist around clayey particles and no water bound compression layer exist around sandy particles. When water flowing through the pores of sandy aquifer material, mineral compound can easily dissolved with the water. But in case of clayey aquifer material, due to strong water bound compression layer and negligible velocity of flow, there is a small possibility of the dissolved of mineral compound with water flowing through its pores. And a detail study is required on the geological, geo-hydrological and physical behaviour of clayey aquifer material.

From the above discussions, one can say that iron content in ground water (I_w) is a function of iron content in aquifer material (Is); effective size of aquifer material (d); and various geological, geo-hydrological and physical factors of the aquifers as:

$$I_W = f(I_S, d, A) \quad (2)$$

The effect of iron content in aquifer material and effective size of aquifer material on iron content in ground water have been discussed.

Considering these factors, equation (2) might be stated by the empirical equation as :

$$I_W = A^* (I_S)^b * (d)^c \quad (3)$$

where, A = Constant for various geological, geo-hydrological and physical factors

b, c = Exponential value

Using the experimental datas, the relationship obtained by the regression of I_W on I_S , d & A as :

$$I_W = 0.59 * (I_S)^{0.708} * (d)^{1.3639} \quad (4)$$

where, $0.088 \text{ mm} \leq d \leq 0.302 \text{ mm}$

the observed and calculated value of I_W are shown in figure 5. Though the points are scattered, there is a reasonable correlation. Moreover, from the analysis it is found that iron content in aquifer material is a more significant parameter than 'd' and 'A' on the iron content in ground water.

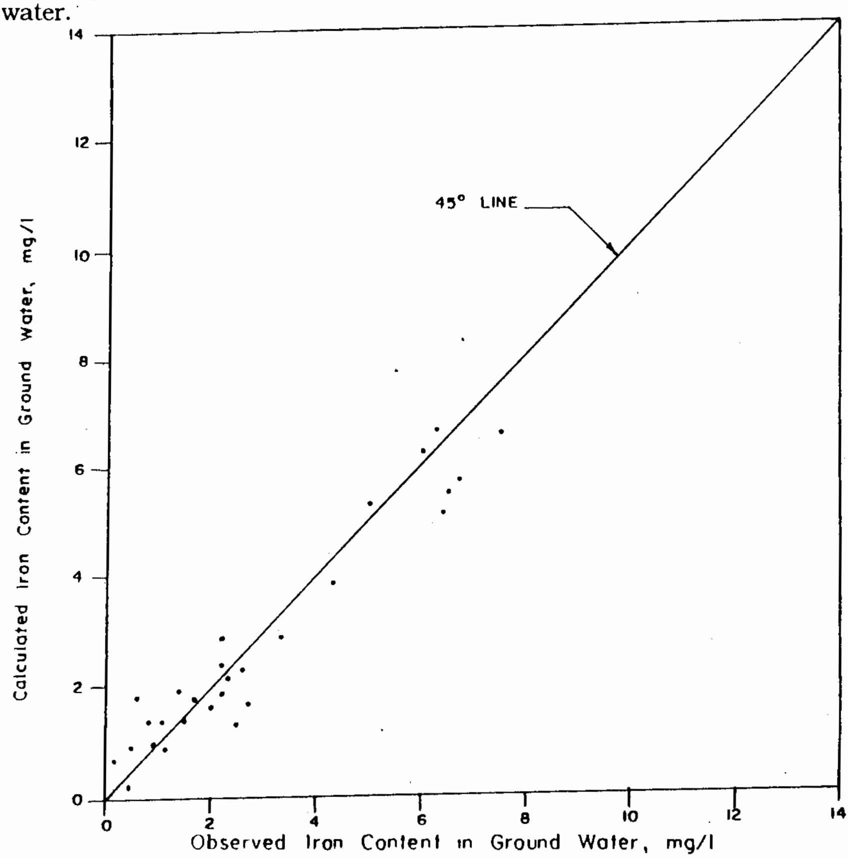

Fig 5. Observed iron content in ground vs. Calculated iron content in ground water

CONCLUSIONS

1. On the basis of a statistical analysis, iron content in aquifer material appears to be the most significant parameter influencing iron content in ground water.
2. The quality of deep tubewell water is suitable drinking water supplies of Bangladesh, except about 4400 sq. km. (3% of the total area) of coastal belts and about 28000 sq. km. (19.5% of the total area) of excessive iron problem (Fe > 5.0 mg/l) areas.
3. In any location, iron concentration in ground water is independent of depth of aquifer.

REFERENCES

Ahmed, F. (1981), "Design Parameters for Rural Water Supplies in Bangladesh", M.Sc. Engg. Thesis, Dept. of Civil Engg., BUET, Dhaka, Bangladesh.

Department of Environment, (1991), "Environmental Quality Standards for Bangladesh", Government of the People's Republic of Bangladesh.

Huda, M.K., (1995), "Ground water Quality in deep Aquifers of Bangladesh", unpublished M.Sc. Engineering Thesis, Department of Civil Engineering, BUET, Dhaka.