ISSN: 0976-3031

International Journal of Recent Scientific Research

Impact factor: 5.114

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Volume: 6 Issue: 9

THE PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH
(IJRSR)
http://www.recentscientific.com
E-mail: recentscientific@gmail.com

Available Online at http://www.recentscientific.com

ISSN: 0976-3031

International Journal of Recent Scientific Research
Vol. 6, Issue, 9, pp. 6031-6035, September, 2015

International Journal of Recent Scientific Research

RESEARCH ARTICLE

SUSTAINABLE GROUND WATER MANAGEMENT OPTIONS IN THE FLUORIDE AFFECTED ALLUVIAL TRACT OF SOUTH DINAJPUR DISTRICT IN WEST BENGAL, INDIA

Anadi Gayen

Scientist 'D', Central Ground Water Board, Rajiv Gandhi National Ground Water Training and Research Institute (RGNGWTRI), Raipur, Chhattisgarh

ARTICLE INFO

Article History:

Received 15th June, 2015
Received in revised form 21st July, 2015
Accepted 06th August, 2015
Published online 21st September,2015

Key words:

Barind tract, Older alluvium, Recent alluvium, High fluoride (>10 mg/l), Ground water management

ABSTRACT

South Dinajpur district lies in the Latitude between 26^0 35' 15" N and 25^0 10' 55" N Longitude between 89^0 00'30"E and 87^0 48' 37" E in northern portion of West Bengal State. The district forms part of Garo-Rajmahal gap and has typical combination of older alluvium (including Barind tract) and Recent alluvium. Coarse to fine sand and gravel forms the principal aquifers. Ground water occurs under unconfined condition in northern part, whereas in semi-confined to confined condition under a clay blanket in the Barind tract. In the tract, the aquifers are fine grained and thinner alternating with thick clay beds. The mode of withdrawal of ground water is through through dug well, shallow tube well fitted with submersible pump and deep tube well (Medium duty) are feasible for irrigation purposes. In the remaining part of the district shallow tube well and heavy duty tube wells are in use. Drinking water demand is fulfilled by hand pump fitted small diameter tube well and through piped water supply from medium duty or heavy duty tube well in city area. Dug well numbers have been decreased at present and used for domestic purposes mainly. Heavy duty tube wells use for irrigation purposes is tapping the aquifers within the depth range of 250 meter below ground level (m bgl). The district consists of 8 blocks, of which 5 are having high fluoride content (>1.5 mg/l) in ground water. Sporadic occurrence of fluoride has been observed in the tube wells. The fluoride content in ground water is increasing with depth in and around the Barind tract. The medium duty hand pump fitted tube well in the tract has.>5mg/l fluoride content, whereas in deeper aquifer fluoride content is as high as >10 mg/l. As the district has diversified hydrogeological set up, ground water management options to be considered with utmost care. In Barind tract, ground water potential is low and drawdown is high. Hence, scope of ground water development is limited in the tract. In older alluvium, dug well, light and medium duty tube wells fitted with submersible pump can be constructed for drinking and irrigation purposes with due care of the capacity of the pump to be used, so that drawdown can be minimized. Heavy duty tube wells should be constructed within the 250 m bgl depth and restricted drawdown to be maintained. In Recent alluvium, both shallow and deep tube wells are feasible and having very good ground water potential for development.

INTRODUCTION

West Dinajpur District was created in 1947 from the Dinajpur district at the time of partition of India. The West Dinajpur district was enlarged in 1956 at the time of reorganization of the state with the addition of some areas of Bihar. The district was bifurcated into North Dinajpur and South Dinajpur on 01-04-92. The district lies between 25°10'55" & 26°35'15" Latitude (North) and 87°48'37" & 89°00'30" Longitude (east). It is bounded by international boundary with adjoining country Bangladesh on the northern, eastern & part of southern side, by Uttar Dinajpur district in western side and by Malda district in part of southern side. The district with an area of 2187 Sq. Km. falls in the survey of India degree sheet nos. 720, 72P, 78C and 78D.

The district with its headquarters at Balurghat can be divided into two sub divisions viz Balurghat Sadar and Gangarampur at Buniadpur and having 4 blocks for each sub-division. The district has two municipal towns at Balurghat and Gangarampur. As per 2011 census, the total population is 1670931 in the district with the density of 753 per sq.km. Bulk of the population lives in rural area and their livelihood and occupation are largely dependent on agriculture. Fluoride affected blocks of West Bengal state has shown in fig.1.

Geomorphology And Drainage Pattern

The general appearance of the district is flat to gently sloping towards south-east following the trend of the rivers and having rolling topography with an elevation varying from 22 to 42

Corresponding author:* **Anadi Gayen
Scientist 'D', Central Ground Water Board, Rajiv Gandhi National Ground Water Training and Research Institute (RGNGWTRI), Raipur, Chhattisgarh

m.amsl. The district can be divided into two district geomorphic units based on physiographic characters viz (i) Barind (ii) Flat Alluvial Plain.

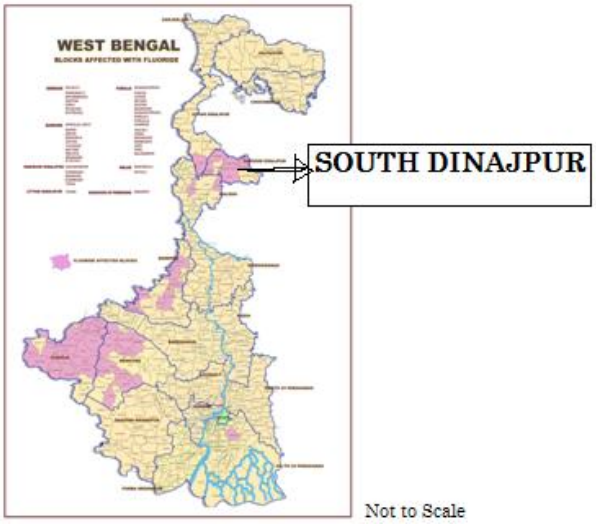

Fig.1 Fluoride affected blocks of West Bengal state

Older alluvial argillaceous (reddish colour) soil is known as Barind and is relatively elevated high land with wide undulating tract and interspersed between shallow stretches to deeper depressions, which are nothing but abundant river channels. This formation occurs in Bansihari, Gangarampur, Tapan blocks of the district (eastern part of the district). The flat and fertile land (Diara) comprises of younger and older alluvial plains, covering most parts of the district are the product of flood plain deposits. (greyish white colour).

The soil composition is mainly consist of loam followed by sandy loam. Largely the soil texture varies from heavy clay to clay loam with poor internal drainage, capability in low land areas (Bils). Sandy loam occurs in highlands and slightly reddish in colour, locally known as "Khiar" which is neutral to acidic in nature. Both transported & residual types of soil are commonly found in the district.

The district is drained by a number of north-south flowing rivers like Atrai, Punarbhaba, Tangon and Brahmani. Most of the rivers enter from Bangladesh through different blocks of South Dinajpur district of West Bengal. All the rivers have full flow during the monsoon period. During non-monsoon period, their flow is sustained by base flow along the channels. Thus non-kharif cultivation in the district has to depend mainly on ground water. So the optional development and utilization of both surface & ground water resources for both drinking and agriculture purpose needs to be restricted with care.

Geology

The district forms a part of the Garo-Rajmahal gap filled up with older and younger alluvium due to the result of shallow subsidence and concomitant deposition in fore deep area in front of the Himalayas in the Pleistocene and Recent periods. The thickness of the sediments is shallower in southern part of the district as is evidenced by the occurrence of coarse grained biotite granite basement rock at a depth of 304.8 m Buniadpur in Bansihari block and sandstone (Tertiary/Siwaliks) at 304 m at Patiram in Balurghat block.

Siwaliks (Wadia & Auden, 1959) underlying the alluvium, overly the basement gneiss. Their buried contact is considered to be an overlap. The Barind consist of well oxidized reddish argillaceous formation (older Alluvium), occur in the east of North Dinajpur district & east of Mahananda river. In the Barind tract, younger alluvium deposits (sand, silt, clay) occur along the course of the Tangon & Purnabhaba River.

The sediments in the southern part of the district in Hilli, Balurghat, Tapan, Kumarganj, Gangarampur & Banshihari blocks is predominantly argillaceous. The top clay bed is lenticular. It pinches out northwest of Harirampur and southeast of Balurghat.

Hydrogeological Scenario

The availability of ground water is more or less limited to unconsolidated alluvium formation of Quaternary age comprising (i) Older alluvium, deposits of discontinuous aquifers (ii) Newer alluvium of regional extensive aquifers. Ground water occurs under unconfined condition in a thick zone of saturation within the alluvial sediments. Several promising saturated granular zones are present in the depth range of 17 to 184 meter below ground lexel. It can be observed that the general predominance of sand over clay in the alluvial formation, the discontinuous nature of clay horizons and commonly the silty characters of the clay layers apparently indicates that the ground water is predominantly under unconfined condition and locally it is under semi-confined condition in the district.

In the northern part of the district, the aquifers are depicted as multilayered fashion. Predomenance of day over sand occurs in Barind tract is restricted in the south western parts i.e. in Bansihari, Tapan & Buniadpur blocks and the yield potentiality of aquifers is not so promising with a maximum draw down. The maximum thickness of porous formation is restricted within 50 m only. However ground water also occurs under semi-confined to confined condition below a blanket of 15-20 m thick clay bed in the Barind Tract available in Bansihari-Tapan-Gangrampur sector.

The ground water occurs under semiconfined to confined condition under a clay horizon in Recent Alluvial Plain available as a patchy occurrence in the eastern part of Balurghat, Hilli and northern part of Kumarganj course to fine sand, gravel deposits in the Recent Alluvium are the main repository of ground water having large yield potentiality.

Lateral facies variation in the sediments in general leads to variations in thickness of aquifers in the occurrence, movement and availability of ground water in different parts of the district. Hydrogeological map of the Dinajpur district has shown in fig.2.

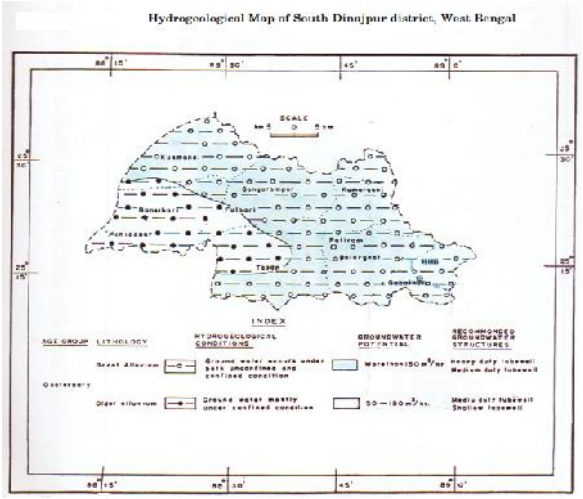

Fig.2 Hydrogeological map of the Dinajpur district

Aquifer Characteristics

The yield potential of the wells (drilled by CGWB & other State Govt. agencies) ranges between 20 to 230 m^{3}/hr and draw down varies from 2.50 to 18.00 m. From the exploration data, aquifers, occur within 50 m bgl at Balurghat, within 150-215 m bgl at Tapan and within 150-200 mbgl at Gangarampur. The Transmissivity of the aquifers as computed by pumping tests varies from 37 to 2000 m^2/day. The discharge of the well at Tapan (in Barind tract) is very less within 50m^3/he with a high draw down of 14-17 m, whereas the discharge is about 150m^3/hr for less draw down of 2-8m at Gangarampur, Balurghat and Banshihari block. It is observed that Transmissivity (T) is higher within 1500-2000 m^2/day in Gangarampur, Balurghat blocks and minimum in Barrind tract in Tapan block.

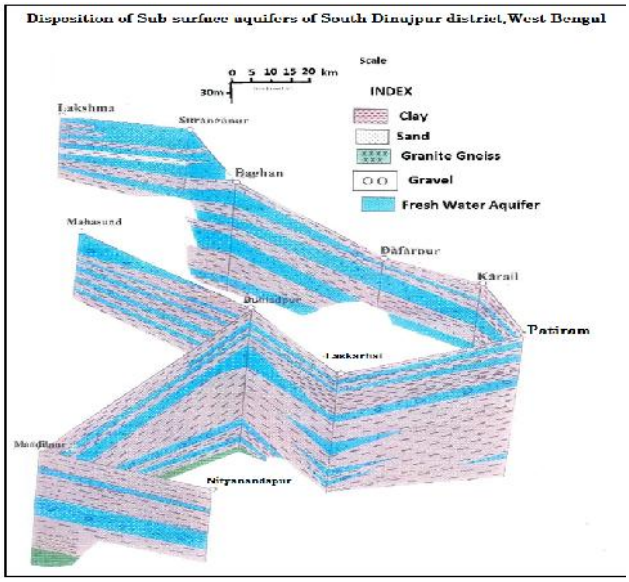

Fig.3 Disposition of sub-surface aquifers of South Dinajpur district

Ground water in the shallow aquifers (within the depth of 80 mbgl) occurs under unconfined condition. The low yielding (25 to 30 m^3/hr) tubes well tapping shallow aquifers are generally fitted with 5 H.P. diesels operated centrifugal pump and are mainly used for irrigation. The heavy duty tube wells are capable of yielding 50-150m^3/hr tapping the deeper aquifers (between 100 to 300 m bgl depth), which are under confined to semi-confined condition. These types of tube wells are developed by electric operated submersible pump used by Public Health Engineering Department (PHED) for piped water supply scheme and also by Agri-Irrigation department. Disposition of sub-surface aquifers of South Dinajpur district has shown in fig.3.

Hydrograph Network Station Monitoring

Depth to water levels have been monitored from 21 Hydrograph Network Stations (NHNS) during four times including pre-monsoon, monsoon & Post-monsoon (November) in every year. Depth to water level of the shallow aquifer varies from 1.14. to 12.29 m bgl during pre-monsoon period and 2.21 to 6.65 m bgl during post-monsoon period. It has been observed that average pre-monsoon depth to water level is deeper in Tapan block (12.15 m bgl), Bansihari block (10.16 m bgl) in older alluvium deposits and it is shallower (6.35 m bgl) in Balurghat block.

The average post-monsoon depth to water level is deeper in Bansihari block (4.73 m bgl) in older alluvium terrain and it is shallower in Kusmandi block (1.87 m bgl). The Maximum fluctuation of water level (8.09 m has been noticed from Tapan block and minimum fluctuation (2.24 m) in Balurghat block other parts of the district it ranges between 2 to 4 m. From the water level data of hydrograph network stations the long term trend of water level between 2000-2010 has been analyzed for pre-monsoon and pre-monsoon period. The considerable declining trend has been observed in Bansihari, Kusmandi & Tapan blocks during pre-monsoon (20cm/year) period, whereas no such declining trend is noticed during post-monsoon period of the district.

Ground Water Resources

The dynamic ground water resources estimation conducted as per in March, 2009, depends on proper quantification of ground water resources and also on assessment of status of ground water, and development in a judicious manner in some fluoride affected blocks.

The level of ground water development has been calculated based on gross ground water draft/net availability of ground water expressed as percentage. The categorization of block has done based on level of ground water development and long terms trend of water level (pre and post). It has been observed that ground water development ranges from 18.88% (Bansihari block) to 54.29% (Gangarampur block. Out of 5 affected blocks (fluoride), 4 blocks have stage of development less than 50%. Categorization of blocks of the study area have been presented in Table-I. It is observed that all the blocks fall under safe category.

Hydrochemistry

Chemical analysis result of Water samples collected from the Hydrograph Network stations has given in table-II.

Table – I Assessment of Block wise stage of Ground water Development of South Dinajpur District (2008-2009) in ham

Sl. No.	Name of Ground water Assessment Unit	Net Ground Water Availability (in ham)	Existing Gross Ground water Draft for Irrigation (ham)	Existing Gross Ground water Draft for Domestic (ham)	Existing Gross Ground water Draft for all uses (in ham)	Provision for domestic & Industrial requirement up to 2025 (in ham)	Net Ground water Availability for future Irrigation development (in ham)	Stage of Ground water Development in %
1.	BANSIHARI	13573.66	2346.30	144.05	2562.38	297.29	10930.07	18.88
2.	GANGARAMPUR	15247.39	7912.50	243.85	8278.27	503.26	6831.63	54.29
3.	KUMARGANJ	14271.97	5781.00	18055	6051.82	372.63	8118.34	42.40
4.	KUSHMANDI	15108.53	7116.00	206.58	7425.87	426.35	7566.18	49.15
5.	TAPAN	18407.96	4461.00	266.75	4861.13	550.52	13396.44	26.41

Table-II General range of chemical parameters of Hydrograph Network Stations

Constituents	Range (ppm)
pH	6.9 - 8.0
TDS	74-579
TH as Ca CO_3	60-725
Fe	.01-8.0
Ca	4 -75
Mg	5.12 –80.84
Na	5.1 - 196
K	0.1-14.06
HCO_3	45-451
SO_4	<1 to 50
Cl	14-579
F	**0.03-0.65(in some places as high as 6.41)**
NO_3	1.6-20

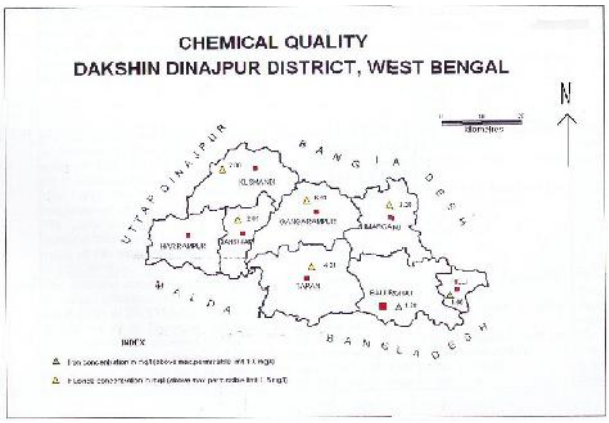

Fig.4 Chemical quality map of South Dinajpur district

Ground Water Quality

In general ground water of shallow & deeper aquifer is potable and by and large within the permissible limits of drinking water standard as referred by BIS. The sporadic occurrence of fluoride more than permissible limit (1.5 ppm) in ground water has been observed in five blocks (Kusmandi, Kumarganj, Bansihari, Tapan and Gangarampur). The maximum concentration of fluoride in ground water has been reported as 2.00mg/l at Kusmandi block, 2.28 mg/l at Kumarganj block, 2.64 mg/l at Bansihari block, 4.01 mg/l at Tapan block and 6.41 mg/l at Gangarampur block. Highest fluoride concentration (10.10 ppm) in ground water has been reported from the deep exploratory well of Central Ground Water Board at Sarbamangala site, Gangarampur block.

The ground water of shallow aquifer is mildly alkaline with pH in the range of 6.9 to 8.0 and Total dissolved solid is within the range of 74 to 579 mg/l. In general iron concentration in ground water of shallow aquifer is high in sporadic manner. The general range of iron in ground water in the study area varies between 0.01 to 8.0 m/l. The shallow ground water is Ca-HCO_3 type.

Ground Water Development & Management

The development of ground water may be done through different ground water abstraction structures considering the occurrence of the potential & potable ground water aquifers and stage of ground water development through proper management so as to yield water at economical rate. The ground water development in the area is mainly related to (i) domestic, drinking and industrial water supply and (ii) irrigation uses.

Ground Water Supply In Urban And Rural Areas

Urban water supply schemes are functional in municipalities of Gangarampur & Balurghat towns through tube wells and pipe water supplies by Public Health Engineering Department and local Municipalities.

Rural water supply schemes are mostly covered by the Panchayets, Block Development offices, partly by PHED & other private tube wells, through construction of different types of hand pumps.

Table–III Irrigation Potential Created From Ground Water Schemes In Five Blocks Of South Dinajpur District (4th M.I. Census, W. Bengal, 2006-07)

Name of the Block	STW		DTW		Utilizable Irrigation potential (ha)	I.Potential created (ha) from Ground water	I.Potential can be created from Ground water (ha)	No. of GW structures Feasible	
	No.	I.P. in ha	No.	I.P.in ha				DTW	STW
BANIHARI	1753	4086.27	03	190.73	21431.51	8568.15	12863.36	22	2569
GANGARAMPUR	5490	11787.26	06	254.00	15181.40	12041.26	3140.14	06	3929
KUMARGANJ	3187	7098.44	23	1378.49	15918.31	8476.93	7441.38	34	2374
KUSHMANDI	4177	9973.88	35	1569.40	14835.65	11543.28	3292.37	39	3324
TAPAN	2637	5602.96	02	91.00	26267.53	5693.96	20573.57	02	1868
TOTAL					**93634.40**	**46323.58**	**47310.82**	**103**	**14064**

Ground Water Irrigation

The ground water is largely used for irrigational purposes through different abstruction structures in fluoride effected blocks of the district. In total 17244 shallow Tube wells and 69 Deep Tube wells are present in five (05) blocks of the district. Ground water development in the district is moderate Number of Shallow tube wells with centrifugal pumps installed by private agencies & other shallow, medium duty and heavy duty tube wells with submersible pumps are in operation to irrigate the areas five blocks. The irrigation potential already created through different ground water structures is 46323.58 ha. The irrigation potential that can be created from different ground water abstraction structure is 47310.82 ha (Table-III).

DISCUSSIONS AND CONCLUSIONS

In five blocks of the district viz Kusmandi, Kumarganj, Bansihari, Tapan and Gangarampur fluoride concentration in ground water above permissible limit (1.5 ppm) is reported in a sporadic manner. The CGWB exploratory well data reveals that concentration of fluoride is increasing gradually downward along with depth, (in older alluvium), which is tapping two or more aquifers in different depths. These tube wells have been constructed for water supply schemes to the users (Panchayets, Municipalities, school and hospital authorities) with a view to delineate the extension of potential zones as well as fluoride free aquifers to the users. The maximum concentration of fluoride in ground water has been reported as 2.00 mg/l at Kusmandi block, 2.28 mg/l at Kumarganj block, 2.64 mg/l at Bansihari block, 4.01 mg/l at Tapan block and 6.41 to 10 mg/lit (at Sarbamangala site) Gangarampur block. The ferromagnesium minerals (reworked) containing fluoride in the basement (either granite or Rajmahal traps) may be the source of fluoride enriched in ground water.

As far as the ground water development (Table-I) in the five fluoride affected blocks of the South Dinajpur district are concerned, they can be categorized as "SAFE". Therefore, large scope of ground water development is available for the agricultural & domestic uses.

Different types of abstraction structures may be installed considering the optimum command area of each structure. It has been observed that the potentiality of the aquifers in Barind tract is low and the draw down is very high. Hence, the scope of ground water development is limited in this area. In older alluvium, dug well, light and medium duty tube wells fitted with submersible pump can be constructed for drinking and irrigation purpose with a care of selecting suitable pump, so that draw down may be minimized. Heavy duty tube wells should be constructed within 250 mbgl depth and restricted draw down should be maintained. In Recent alluvium, both shallow and deep tube wells are feasible and having very good water potential for development. The application of modern techniques like sprinkler and drip irrigation will help increase crop yield and consequently conserve ground water in the older alluvial areas. Different types of water conservation structures like construction of reservoir ponds, check dams across the nalas, rivers Tangon, Purnabhava may lead to recharge shallow tube wells in the barind tract area. Proper care should be taken for construction of domestic tube wells (both shallow & deep) in fluoride infested areas. The potentiality of deeper aquifers (fluoride free) may be explored and be utilized by applying cement sealing technique against thick clay layer existing at top of the deeper aquifers.

Acknowledgement

The author is thankful to the Regional Director, Central Ground water Board, Eastern region, Kolkata for assigning this field study and also thankful to the Regional Director, RGNGWTRI, Raipur, Chhattisgarh for according kind permission to publish the paper in the journal.

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How to cite this article:

Anadi Gayen.*2015*, Sustainable Ground Water Management Options In The Fluoride Affected Alluvial Tract Of South Dinajpur District In West Bengal, India. *International Journal of Recent Scientific Research, 6(9),pp. 6031-6035.*

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International Journal of Recent Scientific Research

ISSN 0976-3031