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APPLICATION OF GIS MODELLING FOR DRINKING WATER AVAILABILITY – A CASE STUDY OF NEEM-KA-THANA MUNICIPALITY, SIKAR (RAJASTHAN)

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Abstract
The availability of drinking water, in respect of quantity as well as quality is a challenge to mankind in present scenario of global/local climate change. The investigation of the issue in the town- Neem-Ka-Thana represents it vividly. Primary data were collected in 26 samples from all 25 wards through interview. The data from various wards of the town result not only the status of Supply Water Facility (SWF) but also the changing pattern of sources of ground water. The growing demand of drinking water has been shifting the source stations to rural areas and consuming the available ground water. The quality of the drinking water is in miserable condition due to high concentration of fluoride (more than 3.8 ppm). With the help of GIS technology, risk zone map has been generated regarding supply and quality of drinking water.

The status has been categories into four risk levels
i.e., (i) very high, (ii) high, (iii) medium and (iv) low.
The risk zone map enables to access, monitor and plans the strategies to overcome the issue.

Keywords: Supply Water Facility (SWF), GIS, Sustainable Development,Fluoride,WebGIS,Drinking Water Requirement (DWR), Drinking Water Status (DWS), ranking scores.

Introduction

Water supply, water quality, and degradation of aquatic environments are concerned sensitively. The concerned is essential to enable the availability of standard amenities as well as to pertain/sustain for the generations to come. Many natural processes and anthropogenic activities affect the interactions of ground water and surface water. Engineering works (constructed or distributed) of all sizes become challenge to provide the facility of water, when and where needed at the different locations. A contraction at a location can fulfill one's demand but other's is affected negatively. The fulfillment of the contemporary needs satisfies but leads to imbalance for the future. If the proper road map for water resource is not maintained in respect of the growing demand of water, it can become complex to resolve. The growing demand of water is associated with the distribution of population. The demand of water increases proportionately to the number of people lives in an area. The study reveals the fact. In the study of water resources in Rajasthan the availability and quality of water become more important due to arid and semi-arid regions. Contaminated water with high concentration of fluoride is noticeable to affect the public health negatively. Fluoride can naturally occur in groundwater and some surface water. Drinking water is normally the major sources of fluoride exposure. Small amounts of fluoride are generally good for people's teeth. According to Bureau of Indian Standards, 1 ppm amount of fluoride is the required amount (Acceptable Limit). The permissible limit of fluoride is 1.5 ppm in the absence of alternate source[1]. But at higher amounts over time, it can cause dental fluorosis and damage people's teeth by staining and pitting. Over many years, fluoride can build up in people's bones,

[1]**BIS** (2009),*Indian Standard Drinking Water- Specification*, Second Revsion of IS: 10500,New Delhi**,** pp.7

leading to skeletal fluorosis characterized by stiffness and joint pain. In severe cases, it can cause changes to the bone structure and crippling effects. Higher amounts of fluoride between 1.5 – 4.0 mg/L can cause dental fluorosis[2].

Study Area

Neem-Ka-Thana is a Municipality (M) class III town according to the population of the towns in 2011 census. The town is located in north-eastern part of Sikar (Rajasthan), at the longitude between 75°45'09''E and 75°49'06''E and latitude between 27°43'19''N and 27°451'031''N. It encompasses a geographical area of 22.50km^2.It lies 422 m to 473m high from Mean Sea Level (MSL). It is the headquarters of Sub-District, Tehsil and Panchayat Samiti of the same name[3]. The distance of the town from Jaipur and New Delhi are 125 Km. and 200 Km. respectively by road.

Methodology

For the study, primary data were collected in 26 samples from all the 25 wards through interview. Secondary data from various organizations are used. The vectorization process of ward boundary is completed with the help of Web-GIS portal of Bhuvan, ISRO and ArcGIS Software. To show the concentration of fluoride; with the help of point input feature Thiessen polygons are created. This tool is used to divide the area covered by the point input features into Thiessen or proximal zones. These zones represent full areas where any location within the zone is closer to its associated input point than to any other input point[4]. The proximal zones of various concentration of fluoride depict the status of the concerned issue. The imbalance of the Supply Water Facility (SWF) and Drinking Water Requirement (DWR) are examined and Drinking Water Status (DWS) zones are created. The ranking scores were given to the different levels and generated risk zonation map showing different intensity of the area in adverse condition.

Results and Discussions

According to Census 2011[5], there are 36,231persons and 6202 households in the town. The population of the town have been increased 253 per cent in five decades (since 1961 census) and 22.62 per cent since 2001.Over the period of five decades; there are different trends of the population in respect of growth rate. The trends of the growth rates are seen from increasing to decreasing order. The various growth rates in different periods are as follows:

Growth rate[6]

Year	1971	1981	1991	2001	2011
Growth Rate (in per cent)	13.16	31.47	45.91	32.66	22.62
Change (+/-)	------	+18.31	+14.44	-13.25	-10.04

[2]**A CAWST** Training Manual (2009), *Introduction to Drinking Water Quality Testing,* Alberta, Canada, pp.152

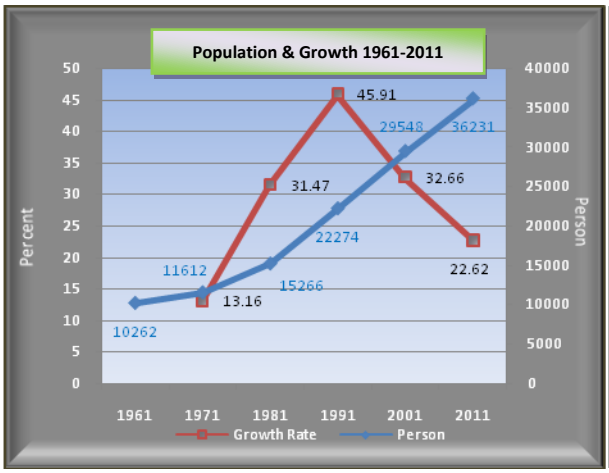
[3]Rajasthan District Gazetteers Sikar (1978), Directorate of District Gazetteers, Government of Rajasthan, Jaipur, pp. 423

[4]**ArcGIS, ESRI,USA**

[5]**PCA,2011** Census of India, Ministry of Home Affairs,GOI

[6]**DCHB Sikar 2001** and **PCA,2011** Census of India, Ministry of Home Affairs, GOI, pp. 365

According to Census 2011, ward no. 15 is the largest populated (2330 person) ward of the town followed by ward no.3 with population 2105person. Ward no. 17 is the smallest populated (830 person) ward of the town followed by ward no. 14 with population 958. Ward no. 15 and ward no. 17 are the largest and the smallest wards with 443 and 142 households respectively. The average households and population of wards of the town are 248 and 1450 respectively. Three largest SC populated wards are 14, 7, and 11 with the percentage of 49.06, 46.06 and 39.26 to the population of the respective wards.



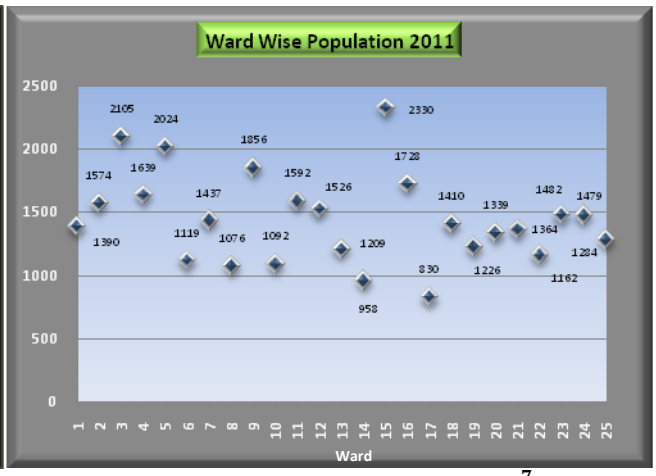


Figure 1: Population and Growth Rate of Neem-Ka-Thana Town[7]
Figure 2: Ward wise Population 2011[8]

The requirement of per day water consumption is 543465 litres in the town. 181155 litres water is required for drinking and cooking purposes daily. Above mentioned rates for all purposes, including drinking, cooking and others, is proposed by public health and engineering department in the bulletin entitled "Jal Sanrakshan Ke Upay"[9].The requirement of water is estimated by the rate of 150 litres/10 person/day. There are 6654 water connection[10] in total. Out of the total, 6168 water connections are for domestic use. These are divided into four chokri: (i) South *(High school-Mohalla Pathwari)*, (ii) North *(Pratap Hostel-Modi Mills)*, (iii) West *(Joshi Colony-Industrial Area)* and (iv) East *(Chhawani)*. There are 1609, 1071, 1318 and 2170 connections in chokri 1, 2, 3 and 4 respectively. Other than the domestic use, 486 connections are used for commercial purposes *(169)*, industrial activities *(104)*, government institutions *(143)* and governed by municipality *(70)*. The water connections for the use of institutions, government, industrial use and municipal public supply are 192, 52, 23 and respectively. There is not fair development of infra-structure in ward no. 12 in respect of urban electricity supply, roads and water facilities. In the ward only 30 % to 40% area is in reach of SWF. Some parts of the ward no. 4, 5, 23, 19 and 13 are with the absence of SWF. The ward wise WR and DWR are given below:

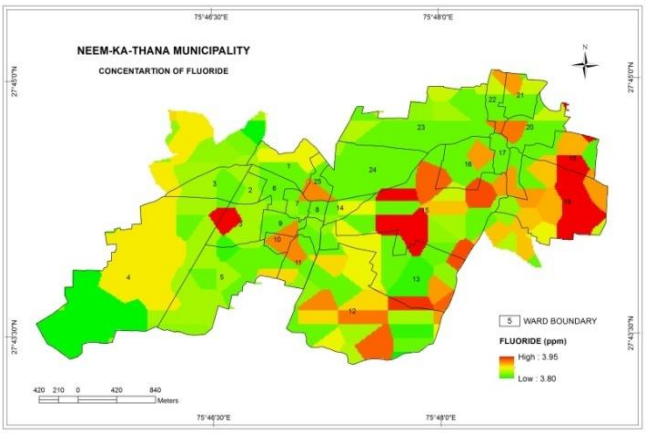
[7]**DCHB Sikar 2001** and **PCA 2011**,Census of India, Ministry of Home Affairs, GOI
[8]**PCA 2011**,Census of India, Ministry of Home Affairs, GOI
[9]**JalSanrkshanKeUpay**, Public Health and Engineering Department, Government of Rajasthan.
[10]**Unpublished Data (SWF Chokri)**, Office of the Assistant Engineer, Public Health and Engineering Department, Neem-Ka-Thana

Table 1: Water and Drinking Water Requirement of the town

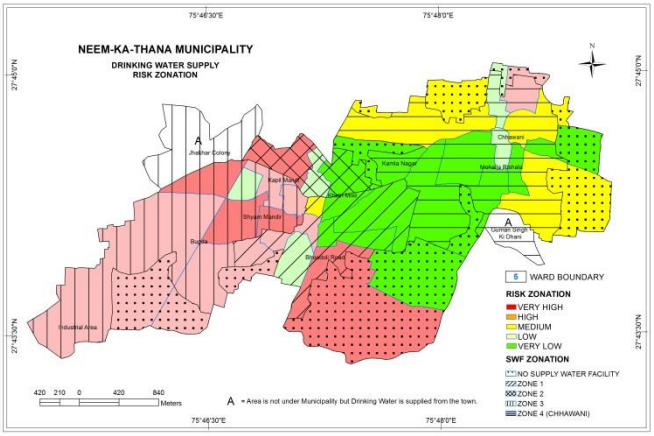
Ward	1	2	3	4	5	6	7	8	9	10	11	12	13
WR	20850	23610	31575	24585	30360	16785	21555	16140	27840	16380	23880	22890	18135
DWR	6950	7870	10525	8195	10120	5595	7185	5380	9280	5460	7960	7630	6045

Ward	14	15	16	17	18	19	20	21	22	23	24	25	Town
WR	14370	34950	25920	12450	21150	18390	20085	20460	17430	22230	22185	19260	**543465**
DWR	4790	11650	8640	4150	7050	6130	6695	6820	5810	7410	7395	6420	**181155**

The concentration of fluoride is higher than BIS standard in the town. The concentration of the fluoride is from 3.80 ppm to 3.95 ppm in whole town, which is at alarming stage.



Map1: Concentration of Fluoride[11]



Map2: Drinking Water-Supply Water Facility Zonation[12]

Modeling of Risk Zonation

As per norms of PHED for WR, the ward wise requirement rates are assessed in tale 1 and in the table 2 ward wise risk areas are shown in different categories. These categories are calculated with the help of data related supply (SWF). For the supply of water, there are various source stations at different locations. With the help of the rising and distribution lines are the part of supply system. There are four types of supply system in the town: (i) Direct Supply or Boosting Supply (ii) Stock Reservoir (SR) Supply, (iii) Single Water Point Supply and (iv) Tank Water Supply.SR is named also Clean Water Reservoir (CWR) Supply, in which the good quality of water is maintained with bleaching powder and other treatment. There are several Bleaching Dowser Points at direct supply lines.

[11] ***SainiPinky and Khan T I (2014),*** *Groundwater fluoride content and Water Quality in Neemkathana tehsil of Sikar (Rajasthan),* International Journal of Basic and Applied Chemical Sciences ISSN: 2277-2073 (Online) Vol. 4 (1) January-March, pp.14-17

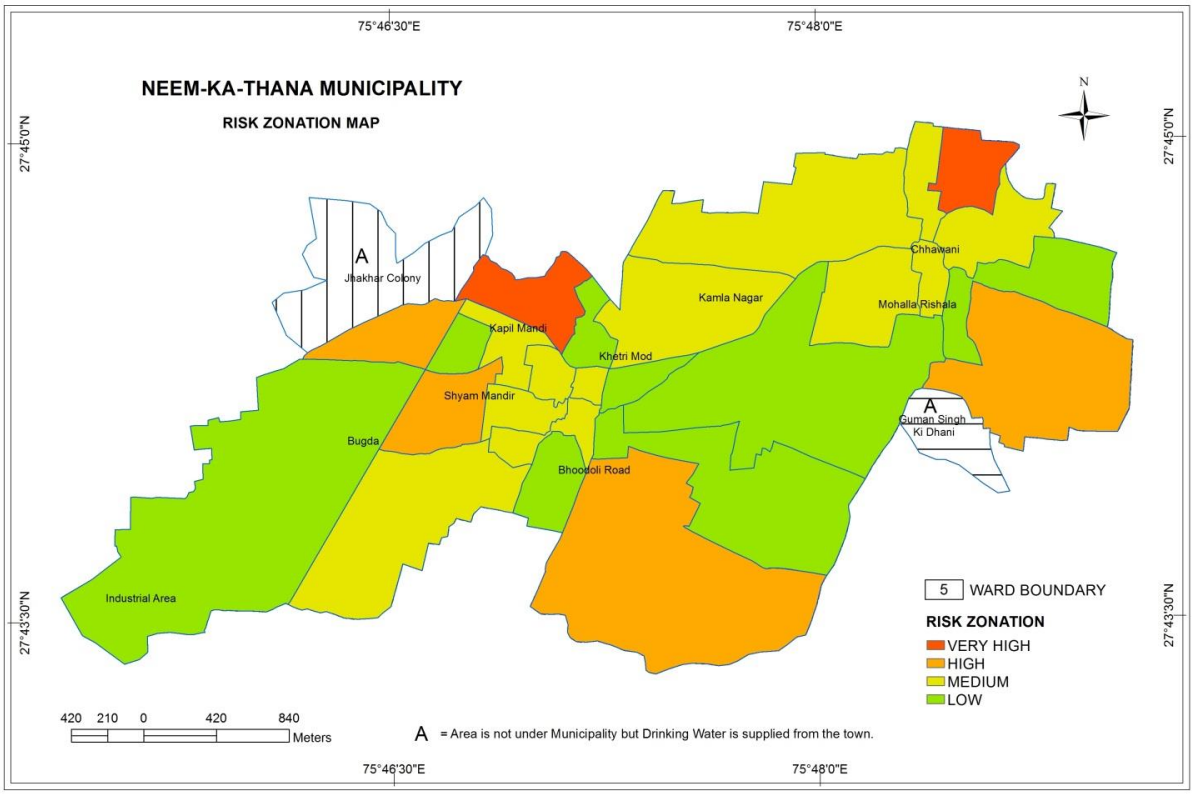
[12] **Unpublished Data (SWF Chokri)**, Office of the Assistant Engineer, Public Health and Engineering Department, Neem-Ka-Thana

Table 2: Risk Zonation of Drinking Water

Level	Ward No.	Water Supply Risk	Fluoride Risk	Risk Zonation
Very High	21	2	1	1
	1	1	2	1
High	19	3	1	2
	3	1	3	2
	12	1	3	2
Medium	16	5	1	3
	17	4	1	3
	22	4	1	3
	24	5	1	3
	20	3	2	3
	23	3	2	3
	6	2	3	3
	7	2	3	3
	8	3	3	3
	5	2	4	3
	9	1	4	3
	10	2	4	3
Low	15	5	2	4
	18	5	2	4
	2	4	3	4
	13	5	3	4
	14	5	3	4
	25	4	3	4
	11	4	4	4
	4	2	5	4

Out of the total area 22.50 Km^2 of the town, 14.36 Km^2 (63.82%) area is supplied water by SWF. But the area of 8.14 Km^2 (36.18%) has no facility of supplied water. As discussed earlier, the concentration of fluoride and SWF in the town shows poor condition of water resource. The table for risk zonation depicts the status of the resource in the study area.

The DWS of the availability and quality water for ward no. 21 and 1 enters in very high risk zone of drinking water followed by high risk wards 19, 3 and 12. In respect of SWF, higher risky wards are 1, 3, 12 and 9. The concentration of the fluoride is very high ward no. 21, 19, 17, 22, 16 and 24.



Map.3: Risk Zonation Map

Conclusion

Ward no. 21, 1, 19, 3 and 12 are in higher risk zones. These are required more effective planning from the local bodies and concerning authorities to get rid of it.

Water Treatment

In the place of ground water use, there are options to free from higher concentration of fluoride into drinking water. The rainwater harvesting during the rainy season is very good alternative not only to lower the amount of fluoride in water but also to recharge ground water. The preserved surface water can be used for drinking or to dilute their groundwater during the rest of the year. In 50 cm rainfall zone, 80% of rainfall water per 250 m^2 surface area 100000 liters water can be stored that can be utilized in drinking and cooking for 150 days by 120 persons.[13]If people change their water source to surface water, they will probably need to treat the water to remove turbidity and pathogens. There are emerging household water treatment technologies that are able to remove fluoride from drinking water, like-Activated alumina, Bone charcoal, clay etc.

Acknowledgement

The authors are grateful to the representatives for wards of Municipal Board of Neem-Ka-Thana, respondents as well government and non-government authorities concerned with the study to provide necessary facilities.

[13]**JalSanrkshanKeUpay**, Public Health and Engineering Department, Government of Rajasthan.

References

1. A CAWST Training Manual (2009), Introduction to Drinking Water Quality Testing,Alberta, Canada, pp.152
2. BIS (2009),Indian Standard Drinking Water- Specification, Second Revision of IS:10500, New Delhi, pp.7
3. Gallo, K. P., Easterling, D. R. and Peterson, T. C., 1996, "The influence of land use/land cover on climatological values of the diurnal temperature ranges". J.Climate, 2941–2944.
4. Yu Haiying, Joshi P.K.,Das K.K., Chauniyal D.D.., Melick David R., Yang Xuefei, 2007, "Land use/cover change and environmental vulnerability analysis in BirahiGanga sub-watershed of the Garhwal Himalaya, India" ISSN 0564-3295,Tropical Ecology 48(2): 241-250
5. Wakeel, A., K.S. Rao, R.K. Maikhuri & K.G. Saxena, 2005, " Forest management and land use/cover changes in a typical micro watershed in the mid elevation zone of Central Himalaya, India" Forest Ecology and Management 213: 229–242.
6. Qion Wu, Hon-qing Li, Ru-song Wang, Juergen Paulussen, Yong He, Min Wang, Bi-hui Wang, 2006, "Monitoring and predicating land use change in Beijing using remote sensing and GIS", Landscape and Urban Planning 78 (2006) 322-333, ELSEVIER
7. Rathore L S, Attri S D, Jaswal A K, 2013, "State Level Climate Change Trends in India", Meteorological Monograph No. ESSO/IMD/EMRC/02/2013, IMD, New Delhi, pp.8,138-142