© 2017 IJSRSET | Volume 3 | Issue 3 | Print ISSN: 2395-1990 | Online ISSN : 2394-4099
Themed Section: Engineering and Technology

Spatial distribution of Uranium in Groundwater of Bathinda District Using GIS- A Case Study

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ABSTRACT

The paper reviews the spatial distribution of uranium contamination in groundwater of district Bathinda using arc-map 10.1. The increased dependency on canal water for both domestic and irrigational purposes has led the groundwater immobile leaving few areas even water-logged. However at other places the groundwater has been over-exploited. This paper reviews the various possible reasons for the uranium contamination. In addition to this the quality of groundwater is degrading with increase in use of phosphate fertilizers. Study deals with the amount of uranium contamination in various villages and towns of Bathinda district. Interpolation tool in Arc-GIS is used to create the spatial distribution map of uranium concentration level. The map directly shows the places with ranges of uranium concentration in various colors.

Keywords: Uranium, Water-Logging, Phosphate Fertilizers, Over-exploited, GIS.

I. INTRODUCTION

High concentration of uranium is found in many parts all around the globe, Finland, Norway, Greece, Canada, Japan and USA [1], [2], [3,] [4], [5]. In India concentrations high concentrations of Uranium are found in districts of Rajasthan, Haryana Himachal Pradesh, Madhya Pradesh, Tamil Nadu, Karnatka etc. Bathinda is located in south-western part of Punjab state, surrounded by Sirsa and Fatehabad district of Haryana in south, Sangrur and Mansa in east, Moga in the north east and Faridkot and Muktsar in northwest. The district has good canal system for irrigation and domestic purposes namely Bathinda branch and Kotla branch canal originated from Sirhind canal. In the last 3 decades it is observed that mortality rate has increased and due to cancer, birth abnormalities in children in the region and this is attributed to higher concentrations of uranium in groundwater. Recently very high values of uranium are reported in the region for example Karamgarh Sattran village(~644ppb) of the area. Uranium is present in earth crust with an average concentration of 0.0003% (3mg/kg). Autunite, Carnotite, Coffinite, Tyuyamunite, Uraninite and Uranophane are the common uranium bearing minerals [6].

Concentration of uranium in groundwater depends on various factors like geological conditions and lithology of the region. Also, it can be caused by human activities like use of phosphate fertilizers, mining and combustion from coal or other fuels, through these activities the uranium gets transported to humans via food and drinking water. Nuclides of uranium emit alpha rays of high ionization power and are hence hazardous.

The amount of uranium indigested or inhaled is harmless if consumed in certain safe limit. This safe limit for the uranium content is recommended by various organizations, in 2004 WHO [7] recommended a safe limit of 15µg/l, UNSCEAR [8] recommended 9µg/l in 2000 and United Nation Environmental Protection Agency [9] recommends 30µg/l in year 2003.

II. Study Area

Punjab state is situated in the north-eastern region of India, covering area of about 50 thousands square kilometres and has a population of around 28 millions. Ropar, Hoshiarpur, Nawanshahr and Gurdaspur districts are mainly covered in sub-Shivalik plain whereas the remaining districts of

Punjab are lying in the Sutlej-Ghaggar River plain [11].

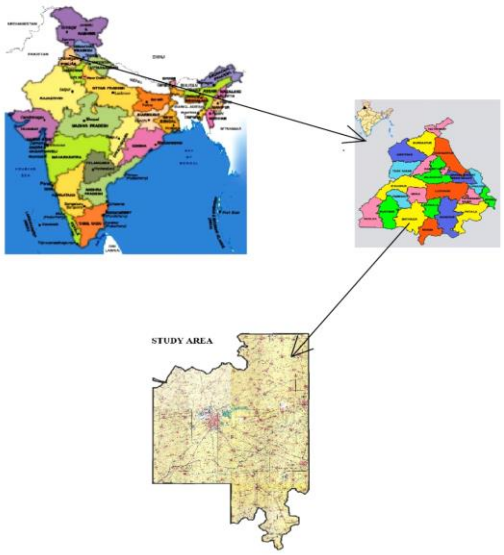

Figure 1: Study Area

Punjab state is one of the most productive agricultural regions, where the agricultural area is cultivated with the help of extensive irrigation using the ground water and the canal water from Beas and Sutlej rivers. Bathinda district is situated in the southern part of Punjab State (Fig1). It lies between 29º33' and 30º36' North latitude and 74º38' and 75º46' East longitude.

Below is the table showing uranium content in different villages of Bathinda district [12]. This table forms the basis for the analysis of uranium contamination in the study area.

Table1: Uranium concentration in 22 villages of Bathinda district

Village name	Average Uranium content (µg/l)	Min value (µg/l)	Max value (µg/l)
Mahima sarja	13.6	10.6	19.4
Ablu	28.2	23.9	32.1
Ramtirath Jagga	29.9	20.1	38.3
Kalalwala	13.3	6.9	16.8
Giana	48.6	2.8	99.8
Malkana	17.6	1.8	59.6
Jajjal	31.8	7.9	63.1
Tungwali	23.3	6.2	33.2
Bucho Mandi	56.9	24.7	74.9
Lehra Mohabbat	23.5	14.6	39.4
Rampura	9.3	5.8	12.8
Nathana	14.7	8.7	22
Gidder	12.9	5.5	20.2
Gobindpura	35	10.6	93.6
Gehributter	35.5	10.8	58
Sanagat	53.9	10.8	87
Jaisingh Wala	52.7	41	61
Multania	24.5	10.8	38.2
Baluana	35	10.6	59.5
Deon	20.8	13.6	27.9
Buladewala	28	18.2	37.9
Bathinda	19.5	1.6	56.5

Some other experts also find the uranium content in the groundwater and had following results:

Table2: Uranium concentration in some other villages of Bathinda

Village name	Latitude	longitude	Uranium content
KaramgarhSatran	30.223804	74.745371	644
Dhillawan	31.520000	75.350000	463
Gudda	30.124476	74.789295	165
Sivian	30.260731	74.899685	25.9
Laliana	31.225899	76.127646	45.2
Goniana Mandi	30.319130	74.914636	12.4
Harraipur	31.062921	75.516751	15.7
Gill Patti	30.2760	74.9400	22

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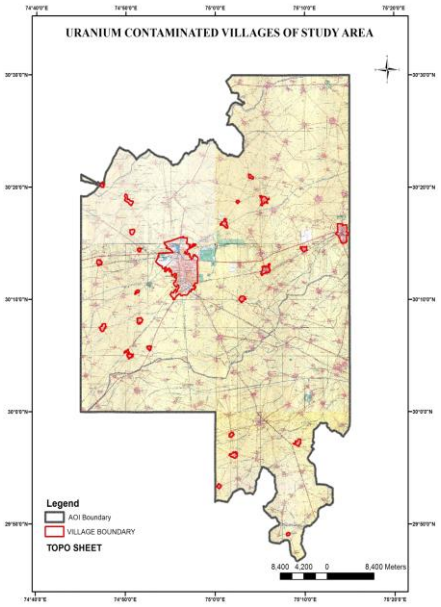
Nehiawala	31.1471 30	75.3412 18	78

Source: [13], [14]



Table

Export_Output

FID	Shape *	village_na	URANIUM_CO
0	Polygon	bathinda town	19.5
1	Polygon	Jaisinghwala	52.7
2	Polygon	Gahri Buttar	35.5
3	Polygon	Sangat	53.9
4	Polygon	Ramtirath Jaga	29.9
5	Polygon	jajjal	31.8
6	Polygon	Malkana	17.6
7	Polygon	Giana	292
8	Polygon	Kalalwala	13.3
9	Polygon	Bhucho Mandi	56.9
10	Polygon	Lehra Muhabbat	23.5
11	Polygon	Rampura Phul	9.3
12	Polygon	Nathana	14.7
13	Polygon	Gidder	12.9
14	Polygon	Gobindpura	35
15	Polygon	Mahima Sarja	13.6
16	Polygon	Ablu	28.2
17	Polygon	Deon	20.8
18	Polygon	buladewala	28
19	Polygon	Balluana	35
20	Polygon	Tungwali	23.3
21	Polygon	Multania	24.5
22	Polygon	Dhillwan	463
23	Polygon	Ghudda	165

1 (0 out of 24 Selected)

Export_Output

Figure 2: Uranium contaminated villages of study area with attribute table.

III. METHODS AND MATERIAL

Materials: Toposheets of study area were collected of the study area. The total area was covered in 5 sheets, Toposheet no. H43P1, H43J4, H43I16, H43I15, H43J3. These hard copy maps were converted into digital form and used in GIS for analysis. Aster data was also collected for analysis.

GIS (Geographic Information System) was used in this study for the spatial distribution of the uranium contamination in the villages. Geographic information system is computer based systems that enable users to collect, store, process, analyze and present spatial data. It provides an electronic representation of information, called spatial data, about earth's natural and man-made features.

Arc-Map 10.1 was used to study the Areal Spread of uranium contamination in the study area. The digital form of Toposheet is referenced to the coordinate system, and then it is mosaic to form a single layer in the tool. The area of interest is then clipped from the mosaic file. After that all the villages are represented in the form of a polygon along with the attribute table of uranium content. This polygon shape-file is converted to point shape-file. Then using various tools from the Arc-Toolbox various maps are generated namely Digital Elevation Model (DEM), slope map, aspect map. DEM is generated from the aster data. Also a map showing the spatial distribution of uranium content in the study area is generated using interpolation tool available in arc-map (Fig3).

IV. RESULTS AND DISCUSSION

From the above studies it is observed that Bathinda district is adversely affected by uranium contamination of the groundwater. Villages like Giana (max uranium content 99.8 µg/l)), Malkana (59.6 µg/l)), Jajjal (63.1 µg/l)), Bucho Mandi (74.9 µg/l)), Gobindpura (93.6 µg/l)), Gehributter (58 µg/l)), Sangat (87 µg/l)), Jaisinghwala (61 µg/l)), Bathinda town (56.5 µg/l)) have values much more higher than the safe limit recommended by WHO (15µg/l), some of them have values 7 times that to safe limit.

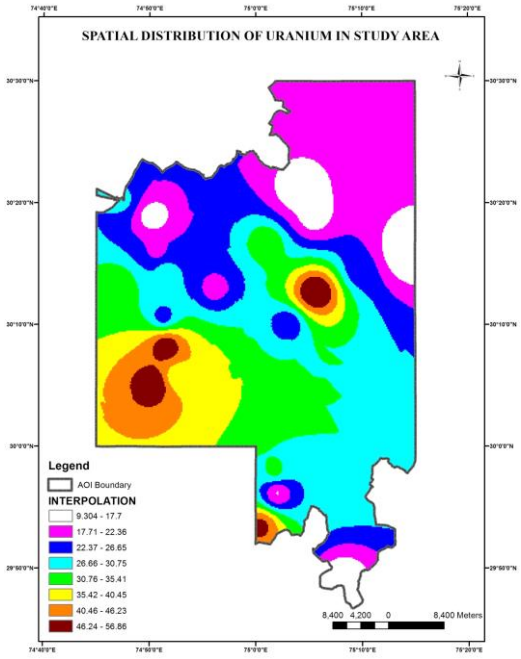


Figure 3: spatial distribution of uranium in study area

V. CONCLUSION

From the above study it is concluded:

- Only the area shown in white colour in spatial distribution of uranium in study area map have uranium content below safe limit and are safe for domestic purposes.
- The study area shows very high concentrations of uranium, maximum being 99 ppb in village Giana.
- If average value of uranium contamination is considered then, only Rampura, Goniana Mandi, Nathana, Gidder, Mahima Sarja, Kalalwala have uranium concentration below permissible limit and the groundwater of these villages is hence safe for drinking.

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