A REVIEW OF ARSENIC CONTAMINATION IN GROUND WATER IN GANGETIC PLAIN AS WELL AS IN PLATEAU AREA OF THE JHARKHAND STATE OF INDIA.

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Across the globe, there are 107 countries and in India 20 states and 4 Union territories have reported the arsenic contaminated drinking water. Jharkhand is one of the Indian states, basically known as “land of forest and tribal people”. The nine districts (approximately 37% districts), out of 24 districts have reported the arsenic contaminated drinking water as reviewed the different research paper. Almost, all 6 districts of Santhal Paragana division of Jharkhand viz Sahibganj, Pakur, Godda, Dumka, Deoghar and Jamtara have reported the arsenic contamination in their drinking water and few districts of Chhotanagpur Plateau viz Giridih, Ranchi and Hazaribagh have also reported the arsenic contamination in their drinking water. The maximum concentration of arsenic is reported 1.5 mg/l, 0.2 mg/l and 1.2 mg/l in Sahebganj, Ranchi and Deoghar districts respectively which is more than the permissible limit of World Health Organization (WHO) Standards (0.01mg/l) and the Bureau of Indian Standards (BIS) ,10500, 2012 (Second Revision) ,amendment, June 2015 (0.01mg/l) .The alluvial soil of gangetic plain and minerals enriched platue are the main sources of arsenic which comes in drinking water either through natural ways and anthropogenic activities such as coal mining and metal smelting of ore processing. The review study reveals that the arsenic contamination in Jharkhand is not only limited to the gangetic plain but also in plateau region.

Key words: Arsenic Contamination, Ground water, Gangetic Plain, Plateau area, Santhal Paragana.

Introduction:

History of Arsenic: The term **"Arsenic"** is derived from the Greek word **"arsenikos"** which means "male" or "virile", further, this is taken in Latin as **"arsenicum"** and in French as **"arsenic".** It has also a origin in Arabic word as **"al Zarnik"** which means "yellow or gold coloured" which is similar to colour of arsenic ores, Orpiment or realgar (**Harper, Douglas 2010**).The use of arsenic is known from the ancient times as either medicine or chemical pigments or as poison to murder the emperor, so it is also called the "king of poison or poison king" (**Vahidnia et el 2010).** It is found in earth crust as at 1.5 ppm and 53rd most abundant element out of the total 80 elements in the earth crust (**John Emsley, 1998**). It is found in the form of compound of iron, sulphur and other metals such as copper and different forms of arsenic ores contain sulphur such as Orpiment (As_2S_3), Realgar (As_4S_4) and Arsenolite (As_2O_3) and others.

The discovery of the arsenic element lies in the work of the Alchemist during middle ages of the world. Around the 300 BC, Theophrastus, Aristotle's pupil, had recognized the two forms what he called it Arsenic, but these were not the pure elemental form of Arsenic. Actually, these were the arsenic sulfides minerals, Orpiment, As2 S3 and Realgar, As4 S4 (**John Emsley, 1998***)*. The toxicity and its use as pesticides in the Rice fields are also mentioned in the Chinese encyclopedia of Pen Ts'ao Kan-Mu. The making of Gold from the arsenic was also written by the Roman writer, Pliny and he wrote that the King Caligula (12-41 AD) had financed one project to make gold from the arsenic but the amount of gold was so little so project was abandoned (**John Emsley, 1998**). Although the arsenic compounds were mined by the Chinese, Greek and Egyptian civilizations but the credit of discovery of the elemental arsenic goes to a German scientist, **Albertus Magnus** in 1250 AD. He heated the arsenic trioxide (White Arsenic, dangerous arsenic) with vegetable oil and got the sublimate which is arsenic (**John Emsley, 1998).**

Study area: The selected study area for review of the arsenic contamination in ground water is Jharkhand which is newly formed state from Bihar at 15th Nov 2000. It lies at latitude 21^0 55' 00" N to $25^0$15'00" N and Longitude $83^0$15'00" E to $87^0$55'00" E. It has 24 districts, 62 Blocks and 32620 Villages and 79714 square Kilometers area. The state Jharkhand is mainly known as the **"land of forest and Tribal"** because major portion of the state is covered by forest as well as

Tribal, which is further divided into the five zones as administrative and political purpose viz Santhal Pargana, North Chhotanagpur, South Chhotanagpur, Kolhan and Palamu. Out of these five zones, the four zones except Plamau are the tribal dominant. It is landlocked state and shared its boundary with Bihar at north, with West Bengal at east, with Uttar Pradesh & Chhattisgarh at west and with Oddisa at south. According to census 2011, it has 32.96 million population out of which 28% is tribal while 12 % people belong to Scheduled Castes. The districts Sahibgnaj, Godda, Pakur, Dumka, Deoghar and Jamtara are lies under Santhal Pragana and the districts East Singhbhum,West Singhbhum, Saraikela are under Kolhan and Garhwa, Palamu (Daltanganj), Latehar are under Palamu division and rest all districts are under the Chhotnagpur. So, the major portions of the state lie on the Chhotnagpur Plateau which is basically made up of Gneisses and Granites lithological. The study areas administrative and natural drainage is shown in **figure-1, figure-2 and figure-3.**

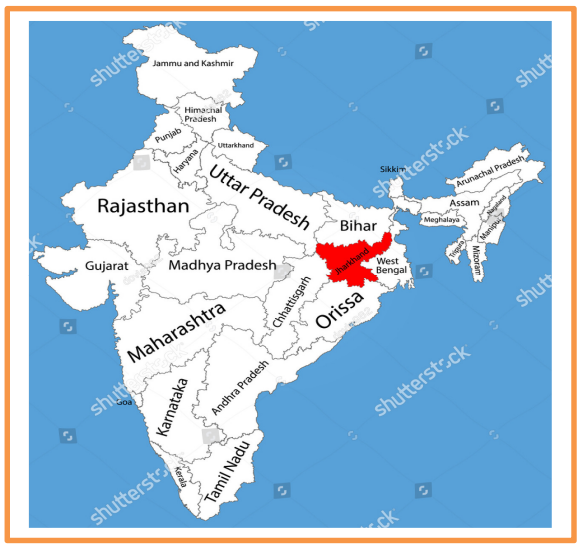


Figure-1: Jharkhand, eastern part of India

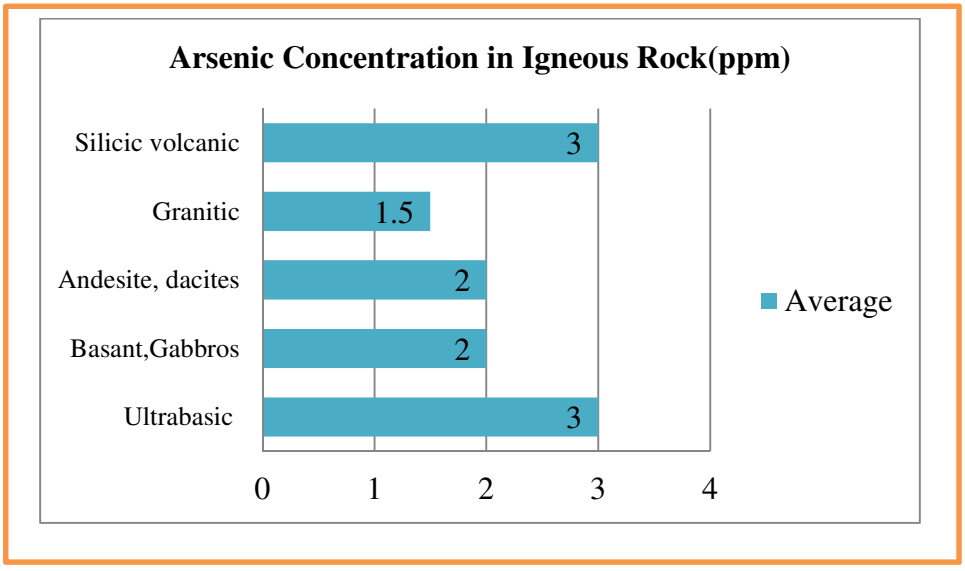
Figure-2: Administrative and Political division of Jharkhand

The rivers such as Ganga, Damodar. Swarnrekha, Barakar, Ajoy, Mayurakshi, Darka, North Koel, South Koel, Sankh and Brahmani are passing through the state. Out of these rivers, the Ganga and its tributary Damodar and the Swarnrekha are the main rivers of the Jharkhand. The district Sahibganj is situated at the bank of the river Ganga and the districts Bokaro, Dhanbad, Ramgarh are situated at the bank of the Damodar River.

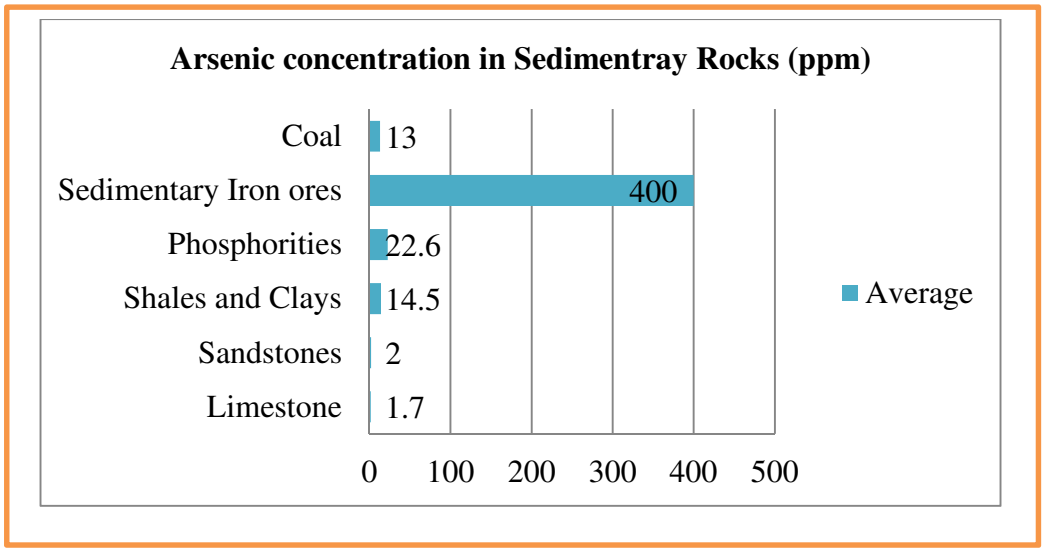
Discussion:

Sources of Arsenic: There are mainly two sources of arsenic in the environment which contaminates drinking water. These two sources are natural and anthropogenic sources.

Natural Sources of arsenic: Arsenic is found in the earth crust and as constituents of 245 minerals species approximately. It is found in the form of alloys (4 minerals), arsenide (27 Minerals), sulfides (13 minerals), Sulfosalt which is the sulfides of arsenic with metals such as lead, copper, silver and thallium (65 minerals) and oxidation products (2 Oxides, 11 Arsenities,116 Arsenates and 7 Silicates) (National Academy of Science. Washington DC 1997). Out of these minerals, the most important are pyrites which contain approximately 5% arsenic content and sulfides and sulfosalts are oxidized readily under the surface conditions (National Academy of Science. Washington DC 1997). In USA, some experts and scientist have done the analysis of Igneous and sedimentary rock to find out the arsenic concentration which is shown below in **graph-1** and **graph-2**. The graph is showing the maximum arsenic concentration in altrabasic and cilicic volcanic in the igneous rock (3.00ppm) and iron containing sedimentary ores (400 ppm) in the sedimentary rock respectively (**National Academy of Science. Washington DC 1997*).***



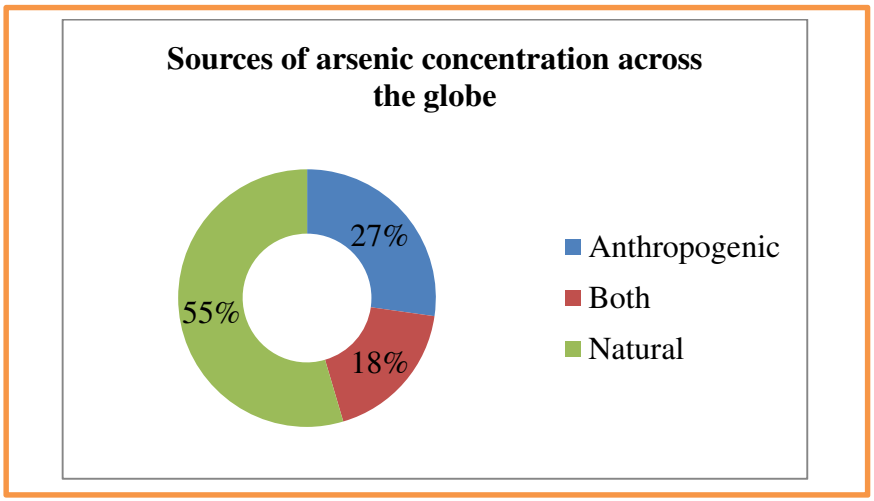
Graph-1: Arsenic concentration in Igneous Rock



Graph2: Arsenic concentration in sedimentary rock

Although, the detailed study of the arsenic concentration in the igneous rock of Jharkhand was not done but the maximum part of the Jharkhand is situated on the plateau of Chhotanagpur which is made up of Igneous Rock, So, the concentration of arsenic shown in graph-1 & 2, may be the strong relation of arsenic contamination in platue area rather than the Gangatic plain area. So, the natural causes of arsenic contamination in the drinking water in Jharkhand is basically geogenic in Chhotangapur platue and arsenic containing alluvial soil in the gangetic plain or its near about area in Santhal Pragana division of the Jharkhand.

Anthropogenic sources of Arsenic: The sources of arsenic which are generated through the human activities are called anthropogenic sources. It is account for 8200 Metric tons per year worldwide (**Bhattacharya P et el 2002**). The anthropogenic sources of arsenic are mining, smelting where, it is found with other metal such as copper, gold, iron etc. Few anthropogenic industrial process directly release arsenic into the environment such as wood preservatives (Chromated copper Arsenate-CCA), mining of arsenopyritie,electrical waste (semiconductors), insecticides, pesticides, weed controller, disposal of industrial and sewage materials and paint products (**Webb J L 1963, Bhattacharya P et el 2007**). Approximately, 55% affected countries have natural sources of arsenic contamination and 27 % countries have anthropogenic sources of contamination and only 18% countries have both sources of arsenic contamination which are shown in graph-3 below:

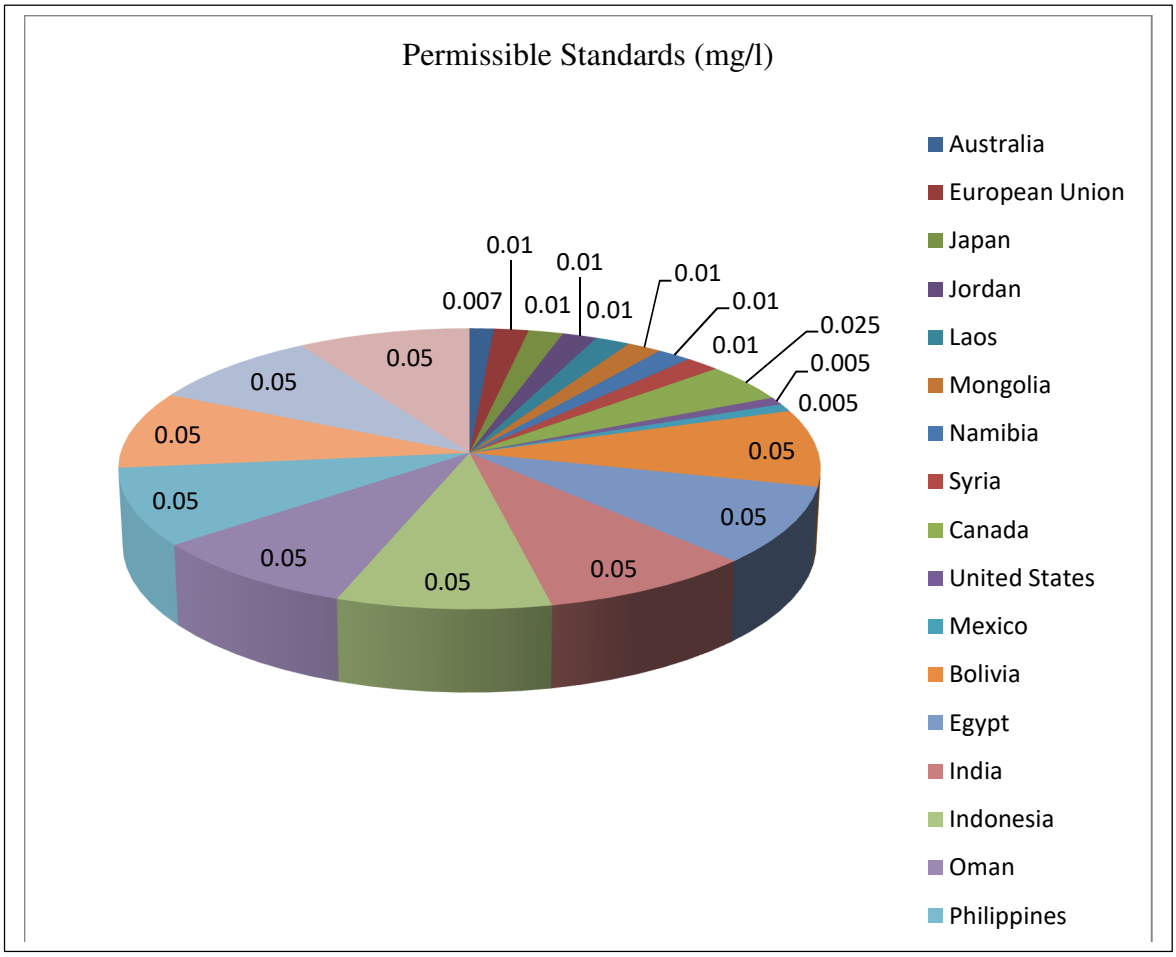


Graph-3: Sources of arsenic concentration across

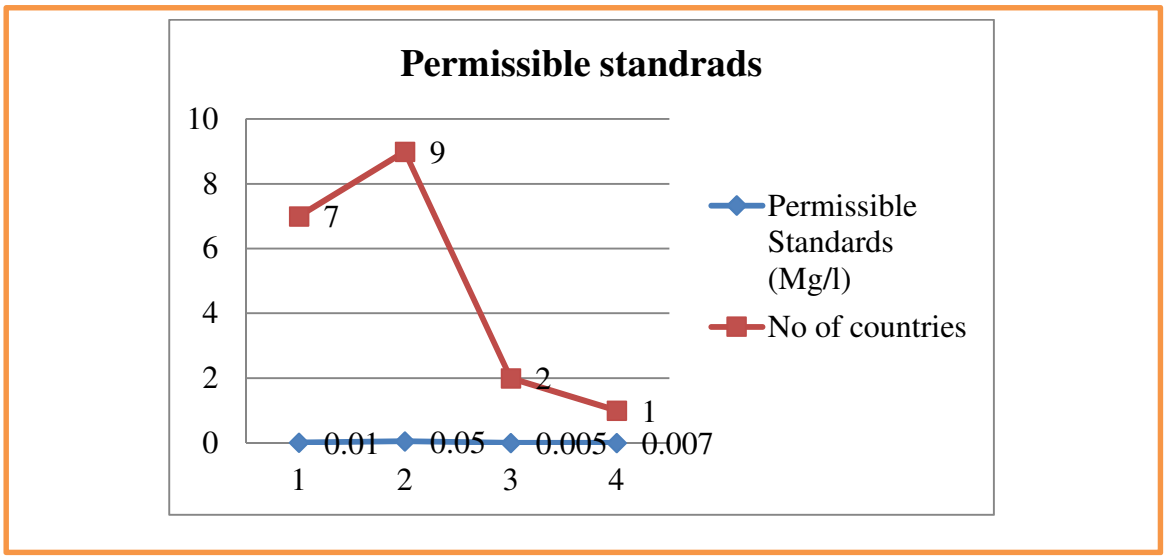
Standards for Arsenic in Drinking water: The history of international standards for Arsenic in drinking water goes back to 1958, when World Health Organization (WHO) had published the first version of "International Standards for Drinking Water" in which it was kept the 0.2mg/l. (**WHO 1958**). In second times, it was reduced to 0.05mg/l by WHO in 1963 without any proper justification (**WHO 1963**). In 1971, 1984, the value of standards was kept same to 0.05mg/l (**WHO, 1971 & WHO 1984**) respectively and in 1993, it was reduced to 0.01mg/l (**WHO 1993**).Several countries have adopted the WHOs recommendation of 1993 version i.e. 0.01mg/l but few countries have delayed and few are still following the previous version of WHOs recommendation i.e.0.05mg/l as shown **in Pie chart graph-4**, below:

Table-1: Standards of Permissibility of arsenic as per different Organization.

SN	International/National Standards	Permissible limit (mg/l)	Year
1	World Health Organization(WHO)	0.01	1993
2	European Union Commission (EUC)	0.01	1998
3	United States, Environment Protection Agency (USEPA)	0.01	2001
4	Bureau of Indian Standards, 10500, 2012 (Second Revision), Amendment June 2015.	0.01	2015

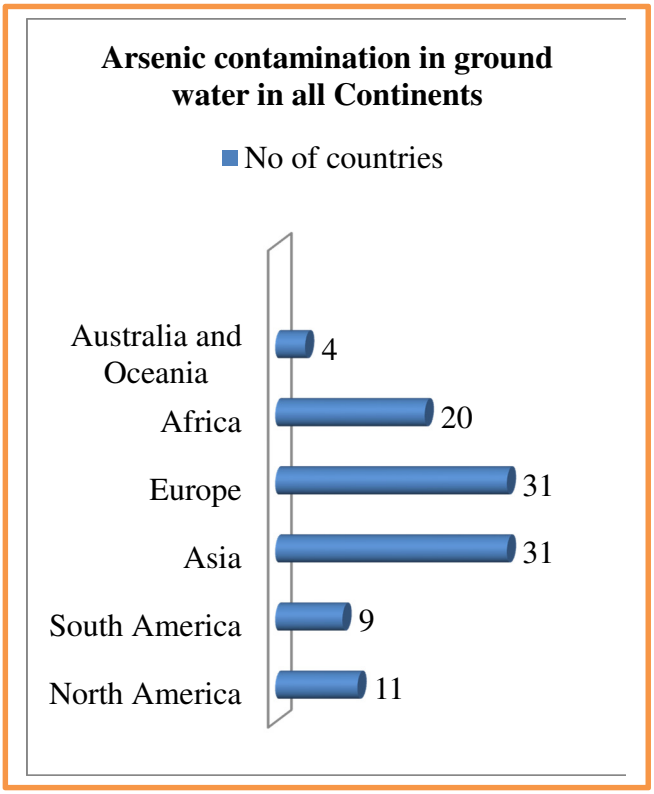


Graph-4: Different permissible standards of Arsenic for drinking water across the

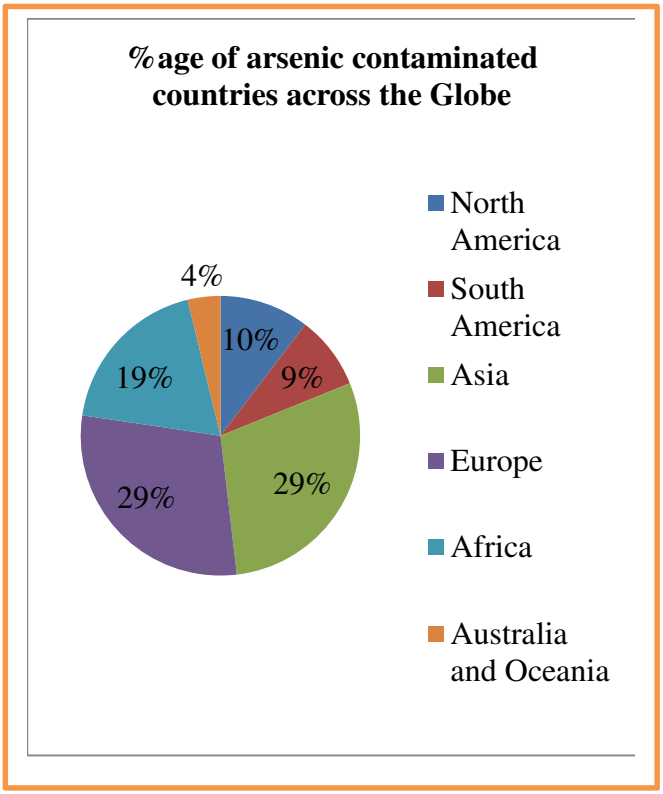


Graph-5: Different permissible standards vs. countries

Arsenic contamination across the globe: First time, arsenic contamination over the globe came in light in Germany in 1885 (**Chakraborti D et el 2019**). In 20th century, nearly five countries viz India, Bangladesh, China, Taiwan and Thailand were reported the arsenic contamination in ground water across the world (**Chakraborti D et el 2019**). But now, the arsenic contamination in the drinking water has reported in more than 100 countries of all five continents of the world. The worst affected continents are Asia, Europe and Africa (E. Shaji et el 2020) as reflected in graph-6 **7 graph-7 as below.**



Graph-6: No of countries affected across the globe



Graph-7: % of countries affected across the globe

Figure-1: Arsenic contamination in ground water across the world (Major countries)

Arsenic Contamination in India: In India, first time, it was reported in ground water in Chandigarh and north Punjab in 1976 (**Nayak Biswajit et el 2008**) and later in four districts of west Bengal in 1983 (**Gajendra Singh K et el 2003**) and its impact on human being was reported with maximum concentration 3.0 mg/nowadays, it is reported that 20 states and 4 Union Territories are affected with arsenic contamination in Ground water (**E.Shaji et el 2020**) such as Bihar, Assam, Uttar Pradesh, Punjab, Haryana, Karnataka and in Jharkhand, which are placed in table-8 and mapped in figure-2.

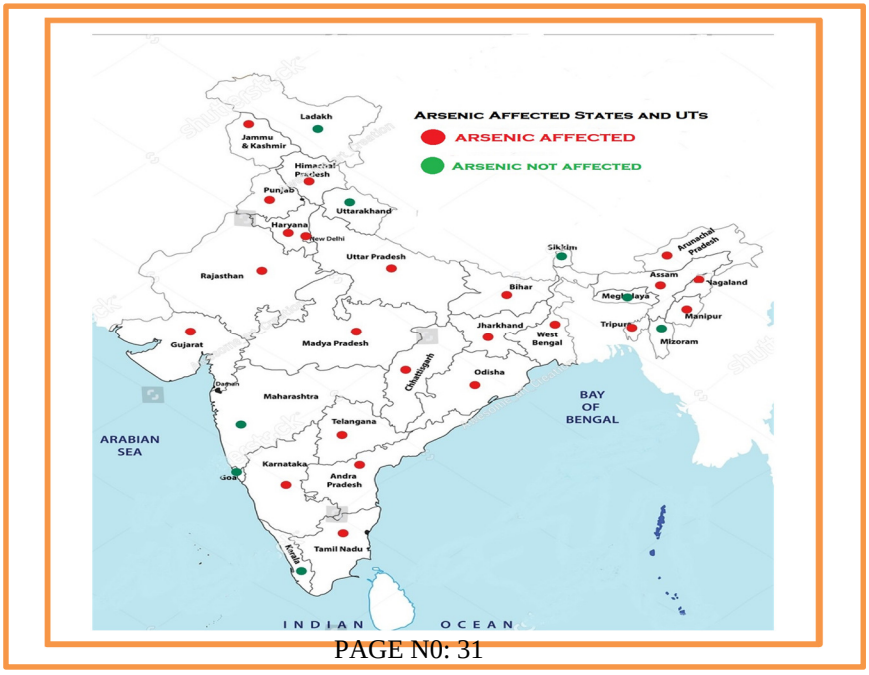


Figure-2: Arsenic affected states and Union Territories

Arsenic contamination in Jharkhand: In Jharkhand, arsenic contamination in ground water has reported first time in three blocks (Udhwa, Rajmahal and Sahibganj) of **Sahibganj district** which is situated at the bank of river Ganga Plain in 2003-2004 (**Nayak Biswajit et el 2008**). The Maximum concentration of arsenic in groundwater in these blocks of Sahibganj district has reported up to 0.09 mg/l (**Nayak Biswajit et el 2008**). In 2014, **Godda district** (Dubey M **K et el 2014**) of Jharkhand under Tribal dominated Santhal Pragana region has also reported the arsenic contamination in both surface and ground water sample in few villages of Barijor block and its concentration was above (0.053 mg/l) the permissible limit of BIS standards (0.010mg/l) . In 2015, Department of civil and Environmental Engineering, Birsa Institute of Technology, Meshra, Ranchi (**Tirky poonam et el 2016**) had conducted the assessment of heavy metals in ground water in **Tunki tola** near kokar industrial peri urban area of Ranchi, Jharkhand and reported that in 15.91% sample in monsoon season having concentration more than BIS permissible limit (0.010 mg/l) and maximum concentration was up to 0.2mg/l. In pre-monsoon season, it was found that only in 3.13% sample having concentration beyond the BIS and up to 0.015mg/l maximum, whereas in post monsoon season, it was found below the detection limit (0.002mg/l). Later, in 2018, it was also reported in **Ranchi urban area**, **Pathalkudwa** of Ranchi districts (**Mausam P Bhengra et el 2018, Tirky Poonam et el 2018**). In 2017-2018, arsenic contamination was also reported in the municipal area of the **Pakur districts** (Saha **Dumraj et el 2017-2018**) in the Jharkhand but the level of concentration was just equivalent (0.010 -0.012 mg/l) to the permissible limit of the BIS standards. In December 2019, arsenic contamination in ground water has reported in Urban area of **Deoghar district** (**Ashok Kumar, 2019**) of Jharkhand and maximum concentration was up to 1.2 mg/l.) . Few districts such as Dumka, Jamtara of Santhal Pragana Division and Gridih, Hazaribagh district of Chhotangapur Platue have also reported the arsenic contamination in their ground water (**Loksabha unstarred question No-387, Ministry of Drinking water and Sanitation Department, Govt of India**).

Table-2: Details of detection arsenic contamination in ground water in Jharkhand.

SN	Districts	Rural/ Urban	Year of Detection	Maximum Concentration (mg/l)	References
1	Sahibganj	Rural	2003	1.5	Biswajit Nayak et el 2007
2	Ranchi	Periurban/ urban	2014	0.2	Punam Tirky et el 2016, Mausam P Bhengra et el 2018 and Punam Tirky et el 2018.
3	Deoghar	Urban	2019	1.2	Ashok Kumar 2019
4	Godda	Rural	2014	0.053	M K Dubey et el 2014
5	Pakur	Urban	2017	0.012	Dumraj Saha et el 2019
6	Dumka	Rural	2018	-	Loksabha unstarred question No-387, to be answered on 19.07.2018. Ministry of Drinking water and Sanitation Department
7	Giridih	Rural	2018	-	Loksabha unstarred question No-387, to be answered on 19.07.2018. Ministry of Drinking water and Sanitation Department
8	Hazaribagh	Rural	2018		Loksabha unstarred question No-387, to be answered on 19.07.2018. Ministry of Drinking water and Sanitation Department
9	Jamtara	Rural	2018		Loksabha unstarred question No-387, to be answered on 19.07.2018, Ministry of Drinking water and Sanitation Department

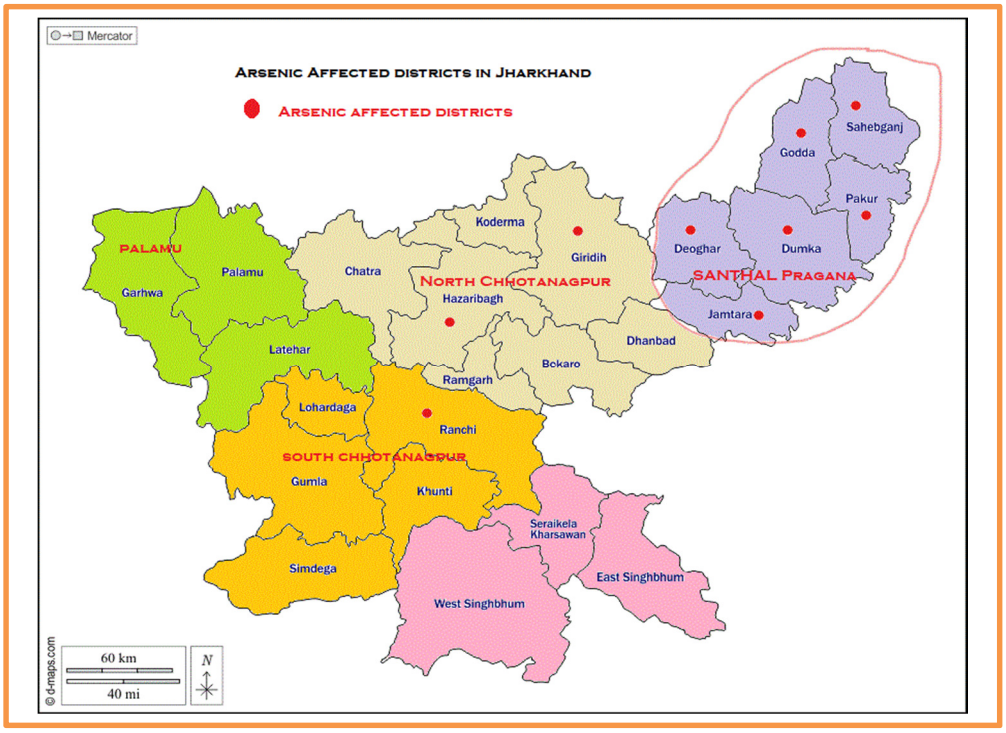
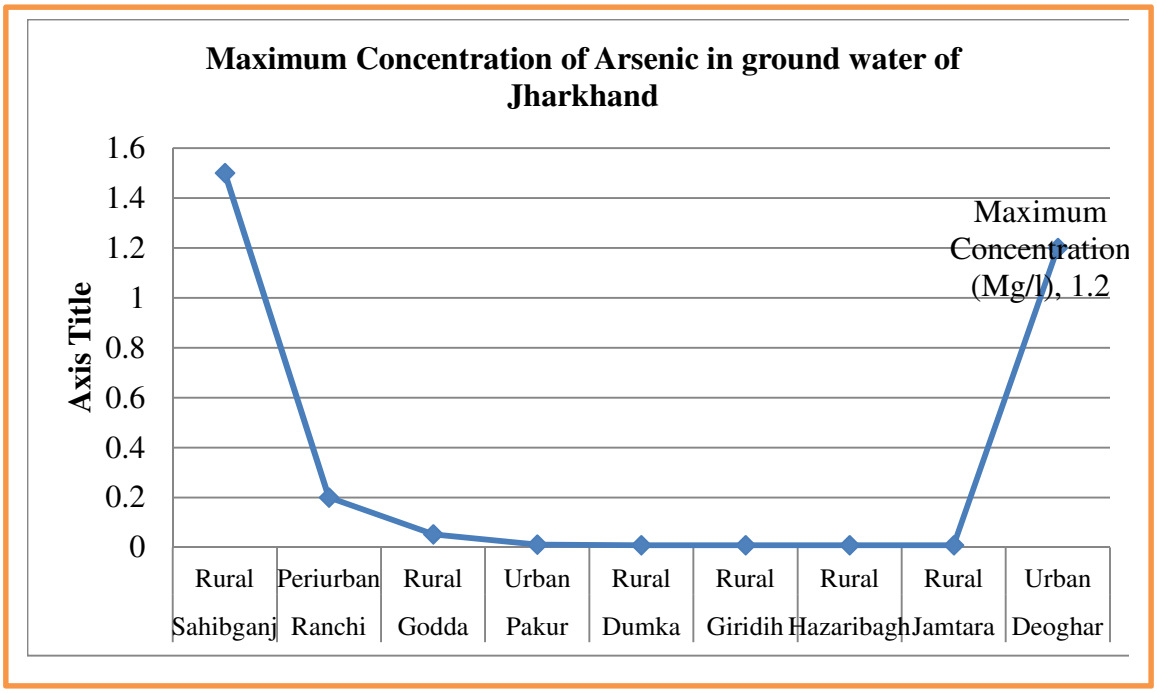


Figure-3: Arsenic affected districts in Jharkhand

Conclusions: As per detailed reviewed of research paper, approximately more than 100 countries across the globe having arsenic contaminated ground water which accounts 29% countries in European and Asian continents. So Europe and Asia are worst effected with the arsenic contaminated drinking water.The natural sources of arsenic are igneous rock and sedimentary rock and the maximum concentration was found in Silicic Volcanic & Ultrabasic Igneous rock (3 mg/l) and sedimentary Iron Ores (400 mg/l). Approximately 55% countries have natural sources of contamination, and in 27% affected countries have anthropogenic sources of contamination and 18% countries have are both, anthropogenic & natural sources of contamination.

There are 9 districts, out of 24 districts of Jharkhand, having an arsenic concentration in their drinking water. Almost, all 6 districts (out of 9 affected districts of Jharkhand) of Santhal Paragana division viz Sahibganj, Pakur, Godda, Dumka, Deoghar and Jamtara districts have reported the arsenic contamination in their drinking water and few districts of Chhotanagpur Platue viz Giridih and Ranchi have also reported the arsenic contamination in their drinking water. The maximum concentration of arsenic is reported 1.5 mg/l, 0.2 mg/l and 1.2 mg/l in Sahebganj, Ranchi and Deoghar districts respectively.



Graph-6: Maximum concentration of Arsenic in ground water of Jharkhand

Different research paper also revealed that the coal mining and metal processing, smelting of copper, having the arsenic contaminated drinking water (**E.Shaji et el 2020**) across the globe. So, in Jharkhand, Bokaro and Dhanbad districts are the coal mining area and East Singhbhum, West Sighbhum districts are concerned to both coal mining and copper smelting process area so, it is the probability of arsenic contamination in these districts also but there is no any detailed study has been laid out in these districts. So, our study of review is going to put the finger to study the arsenic contamination in Kolhan division (East Singhbhum, West Singhbhum and Saraikela) also. The review study also reveal that the arsenic contamination in Jharkhand is not only limited to the gangetic plain but also in platue region. All 9 districts except Sahibganj are at the plateau area. Only Sahibganj district is under the gangetic plain. So the graph-6 is clearly showing the arsenic contamination in gangetic plain as well as in plateau are of Jharkhand. But the maximum concentration is found in gangetic plain than the plateau area.

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