International Journal of Technical Innovation in Modern Engineering & Science (IJTIMES),(UGC APPROVED)
Impact Factor: 5.22 (SJIF-2017),e-ISSN:2455-2585
"International Conference on Modern Trends in Civil Engineering"(ICMTCE-2019)
(Towards Sustainable Development Goals)
Volume 5, Special Issue 02, Feb.-2019

A REVIEW OF GROUNDWATER QUALITY ISSUES IN INDO-GANGETIC PLAINS OF UTTAR PRADESH AND THEIR REMEDIAL MEASURES

Pragya Singh

Department of Civil Engineering, Shree Ramswaroop Memorial Group of Professional Colleges , Tewariganj, Faizabad Road Lucknow

Abstract: ***Various contaminants had already been reported polluting the groundwater resources of Uttar Pradesh. Consumption of unfit drinking water may lead to various health hazards. These hazards may be due to presence of pollutants like fluoride, nitrate, arsenic, salinity, TDS, heavy metals, etc. This paper highlights the various types of contaminates in groundwater of the Indo-Gangetic Plains. It also highlights the mechanism of groundwater contaminations which could be due to natural and/or anthropogenic activities. Various remedial measures are also discussed that could be used to provide safe drinking water. It was realized that there are few drawbacks in the old established technologies for these remedial measures, like the operating and purchasing of few techniques are expensive and need electricity, few techniques have disposal problem of adsorbent, few of them need skilled persons for operation and maintenance, etc. Thus, there is an alarming need to develop a new kind of filter for consumption of safe drinking water specially for the rural population living in the area. The paper also highlights the various types of bio-adsorbent materials that could be for making a cost-effective filters that would be easy to operate and maintained by rural people.***

Key Words: Contaminants, Groundwater, Remedial measure, filter, cost effective, Bio-adsorbent.

I. Introduction

We all are well aware about the availability of water and quality of water present on the earth's surface. Approximately earth surface is covered by 72% of water but 97% of that water is salty and not suitable for domestic and drinking purposes Based on availability and demand of usable water one third of the world population lives in water stressed countries. These countries are recognized as moderate to high stress who use 20% more water, then their available supply In India also there are various issues related to groundwater contaminations. High alkaline water with higher concentration of fluoride has been found in the **villages of Haryana** which is dangerous to human health**.[Bishnoi and Arora (2007)]** Ground water quality **of Tumur Taluka of Karnataka** is also not fit for drinking purpose because the presence of **TDS**, fluoride, bicarbonates, chloride, Manganese, and Hardness**.[Namasivayam & Sangeetha (2005),]** People of **Dwarka** at Delhi are bound to consume very poor quality of groundwater**.[Dubey,et.al (2014)]** .Groundwater of Tamilnadu is unsafe for drinking purpose due to presence of high content of fluoride **[kumar & Kumar(2011),]** . However, in Indo-Gangetic plains the most commonly found groundwater contaminants are fluoride, nitrate, salinity, iron and heavy metal like arsenic. The major part of the State of Uttar Pradesh falls in Indo-Gangetic plain, which is not only known to have vast Ground Water Resources potential but also comprises one of the largest aquifer systems in the world. But, over the last 3 decades, Ground Water Scenario in the state has completely changed, mainly because of indiscriminate exploitation and improper & unscientific management practices both in rural and urban segments, leading to a stage of 'Hydrogeological Stress'. The low rainfall has also aggravated the problem.

Jal Nigam of Uttar Pradesh in (2005-2008) categorized the groundwater based on presence of arsenic into three categories depending on the severity of the **contamination [Report presented by CGWB Faridabad(Ministry of Water Resource) in Febrauary,2014] and [Report of Jal Nigam (2005-2008)]. Indian Institute of Toxicology** in 2014 confirmed that approximately people of all age group in **Raebareli** district are facing risk of fluorosis. The 90% villages of Dalmau block, 65% of villages in Amawa, 50% in Deeh and 53% of villages in Unchahar block 53% are reported to be adversely affected by the fluoride contaminant in groundwater **[Report of Indian Institute of Toxicology,(2014)].** The groundwater quality of **Deoria** district meets the requirements of BIS standard except for salinity where suitable treatment is required to keep alkalinity within standard limit**.[Verma et al,(2014)].**
Variation in concentration of arsenic has been found with variation in depth and horizontal distance. In **Gazhipur** district concentration of arsenic has been found variable at various depth like at the depth of 30 to 33 mbgl higher concentration and at other depth lower concentration.**[Saxena et al (2014)]** In **Unnao** district at same groundwater depth fluoride concentration was higher at Marksnagar village while lower concentration at Durgajkheda village was reported, **[Kumar and A. Saxena (2011)].** Groundwater of **Bhituli , Madiyav , Kallipashim, Draog Akheda and Ganeshpur of Lucknow** is unsafe for drinking purpose. [3]. Arsenic contamination in groundwater around the **Ghazipur and Ballia districts**, of Uttar Pradesh was detected and the concentration of arsenic was found as high as 200µg/l**.[Tripathi,et al (2014)].** Nitrate and nitrite was found variable limit in groundwater sources of **Lucknow.[Verma et al (2014)].** Sources of groundwater in some parts of Unnao contain iron and fluoride ions which were beyond the permissible limits of

BIS.**[Goyal et al (2014)]** At Agra district various physicochemical parameters like **TDS**, F−, Cl−, NO3−, Mg2+, Na+ in most of the groundwater samples exceeded the BIS and WHO permissible limits for drinking water, which may substantially harm the health of the residents in the area **[Yadav et al,(2018)].**

II. Adverse Affect of Groundwater contaminants

Contaminated groundwater can affect health in various ways .From many decades people who are consuming contaminated groundwater facing general to severe health hazard. More than 2.6 billion people of the world's population are facing lacking of basic sanitation facilities and over one billion people still consuming unsafe drinking water sources **[Pandey S (2012),].** As a result of consuming unsafe drinking water more than 2.6 billion people are facing health problem. Approximately thousands of children die every day from diarrhea and other water, sanitation and hygiene-related diseases and many suffer and are weakened by illness [R**. A. Mandour, (2012)]. Bacterial diseases** like headache, nausea, **viral disease** like hepatitis, liver infection severe case of coma, paralysis poliomyelitis and **parasitic disease** like cryptosporidiosis, stomach cramp, poor immune system are serious health hazard affect of groundwater contamination **[Baei et al,(2016)].** Many people are suffering from a variety of health problems including skin, diarrhea, dysentery, respiratory illnesses, anemia and complications in childbirth. Yellow fever, cholera, dengue, malaria , respiratory problems and other epidemic diseases are also has been address in the people who were consuming contaminated water**.** [**Haseena et al ,(2017)]** Groundwater is highly contaminated with total dissolved solids are prone to the health problems such as stomach diseases, gastric troubles etc. **[Halder and Islam (2015)].** Residents using contaminated water had stained/mottled enamel teeth which resulted from the intake of excess levels of fluoride during the period of tooth development. Arsenic contamination of groundwater has increased at a higher rate in last one decade in four villages of Vaishali district. Presence of arsenic in the blood samples of all the age groups are very alarming. **[Kumar et al ,(2017)].** The most severely affected district by fluorosis disease in Uttar Pradesh are Unnao, Raebarelie, Sonbhadra, Greater Noida, etc. Similarly, Lakhimpur, Gazipur and Ballia are severely affected by arsenic contamination and most of the rural people are affected by arsenicosis. The patients of blue baby syndrome due to drinking of nitrate contaminated groundwater in districts like Ghaziabad, Raebarelie, etc. had also been reported. People living in various districts of Uttar Pradesh like Firozabad, Manpuri, Agra, Mathura, Aligarh, etc. have also been reported to be suffering from indigestion problem, typhoid, staining, cholera, salty water, etc.

III. MECHANISM OR SOURCES OF GROUNDWATER CONTAMINATION

In Uttar Pradesh, the groundwater pollutants mainly reported are arsenic, fluoride, nitrate, iron, chromium, salinity, etc. These pollutants may be due to geogenic or anthropogenic activities. There are various studies reported the probable mechanism behind the release of these pollutants into the groundwater. **Kumar and Saxena (2011)** had concluded in their studies that the fluoride contamination in the groundwater of Indo Gangetic Plains are mainly geogenic in nature. **Saxena et.al. (2014)** had confirmed the geogenic activities responsible to release the arsenic in groundwaters of Ghazipur and Ballia districts. However, the degradation of groundwater quality is also increasing because of in-adequate collection of sewage, garbage leading to accumulation of wastewater, improper maintenance of hand pumps, improper sanitation and unhygienic conditions around the structures **[Sukumaran et al ,(2015)].** Function of many factors such as availability and solubility of fluoride minerals, velocity of flowing water, temperature, pH, concentration of calcium and bicarbonate ions in water may be also a major causes for fluoride occurrence**.[Bishnoi and Arora (2007)]** The chief sources of water pollution are sewage and other waste, industrial effluents, agricultural discharges and industrial wastes from chemical industries, fossils fuel plants and nuclear power plants. They create a larger problem of water pollution making it unfit for drinking, agriculture and, as well as for aquatic life. **[Pandey S (2012),]**. **Goel et.al. (2018)** had found in their studies that leaching of polluted water from rivers like Gomati in Lucknow city had also resulted in elevated concentration of pollutants like nitrate in the groundwater of the nearby areas. Higher concentration of nitrate in groundwater may also be due to excessive use of fertilizers, pesticides and insecticides [**Khandare (2013)].**

IV. REMEDIAL MEASURES

In India groundwater is extensively used by rural and urban people to meet out their daily demand. We are more concern to provide safe drinking water to the people. Consistently increment of groundwater pollution is a serious matter of concern. There are various techniques available to provide safe drinking water. Available and currently used methodologies are Reverse Osmosis, Ion Exchange, Activated carbon , Activated alumina, adsorption properties of perlite and zeolite. Various remedial measures have been already in use to remove above discussed contaminants of groundwater.

Fluoride: Fluoride can be remove by various ways like **Precipitation technique (Nalgonda Technique) Adsorption technique** (Activated Alumina, Bone char, Brick pieces column, Mud pot, Fill and draw technique for small communities) **Ion-Exchange technique** ,**Reverse osmosis and electro dialysis**,.

Nitrate: $ZnCl_2$ is an effective way of removal of nitrate**[Namasivayam & Sangeetha (2005),]** .The conventional coagulation process using alum and ferric chloride could be effective in removing nitrate at concentrations less than 50 mg-NO_3/L; ferric chloride exhibited a greater removal efficiency than alum. **[Ahmad et al ,(2016)]**. There are, however, several methods that can be used to reduce nitrate concentrations in potable water supplies with varying degrees of efficiency.
Arsenic: Iron Oxide Filter Systems, Reverse osmosis and distillation is very effective measure to remove arsenic at acceptable limit .Anionic Exchange Systems, Co-Precipitation, Coagulation, and Filtration method is widely accepted., Arsenic Removal by Layered Double Hydroxide (LDH), and Activated Alumina (AA), is very much effective. Arsenic Sorption by Laterite and Limonite with Oxidation is a good option to remove arsenic from groundwater**.[Jiang et al,(2012)]**
Salinity: Reverse osmosis, distillation, De-ionization, membrane technology is effective measures to control salinity in groundwater. Application of fabric columns for removal of salts from saline water is acceptable.**[Abu-Zreig et al, (2006)]**

V. LIMITATIONS OF AVAILABLE TECHNOLOGY TO REMOVE COMTAMINANTS FROM GROUNDWATER

The main limitations of the above removal techniques may be but not limited to high operational and maintenance costs, generation of toxic sludge and intricate process included in the treatment. However, limitation of few specific techniques are discussed as follows:
Precipitation and coagulation method required chemical dosages which are high $Al(OH)_3$ upto 700 – 1200 mg/l). This method has problem in sludge transfer thus require skilled labors.[**Waghmare, and Tanvir (2015)]** Precipitation/co-precipitation is widely used due to high treatment efficiency for heavy metal pollutants but sludge production and its handling cost is the basic limitation for its use at household level .**[Jiang et al,(2012)]**.
Reverse Osmosis is non-attainable for rural regions and is expensive also. Using this technique results in lots of loss of water as waste saline solution and disposal of this salt water is an issue**.[Waghmare, and Tanvir, (2015)].** It removes valuable minerals which are basically required for the human heath thus if this technique is used then we require re-mineralization after treatment. Reverse Osmosis wasted lots of water as brine and expensive also**.[Ingle et al ,(2014)]**
Electro dialysis only separate ionic components and it require potential formation of hydrogen in the electrode rinse. This technique requires lot of power consumption.
Ion exchange technique is exceptionally costly and pH of treated water is low and contains high concentration of chloride**.[Waghmare, and Tanvir].** Ion exchange and membrane technology can be very effective for As removal, but capital investment/operating costs are too high and thus local communities in the developing countries cannot afford them.**[Jiang et al,(2012)]**.

Technique of **ion exchange** require regeneration after every 4-5 months. Disposal of pollutant laden sludge is also a problem. Moreover, this method require skilled personnel and this technique is also expensive because of the cost of resin. **.[Ingle et al ,(2014)]**

Adsorption method have problem in disposal of depleted adsorbents and concentrated regenerated. The another drawback is effectiveness in removal of pollutants after regeneration step and require highly pH subordinate**.[Sanghratna et .al (2015)]** . Nalgonda techniques need a trained operator for daily operations. Pure water may contain excess aluminium which can lead it to cause Alzheimer's disease. Another problem with this techniques is that discarding the sludgeNalgonda process also has low adsorption capacity, poor integrity and needs pre treatment..**[Ingle et al, (2014)].**

VI. BIO-REMEDIAL MEASURES

These days the bio-remedial measure are found to be very effective for removal of groundwater contaminants. The basic principal of this technique is adsorption. The bio-remedial adsorbents are converted into charcoal and are then used as filter media to remove the pollutants. The bio-remedial measure for few of the pollutants are discussed below:

Fluoride: The most suitable bio adsorbent that can be used for fluoride removal is **C. vulgaris [Piddennavar Renuka, & krishnappa Pushpanjali,(2013)], M. stenopetala seeds are also effective bio-adsorbent to remove fluoride [35]. Biomass of the Ulva fasciata** has been identified as a good bio adsorbent for fluoride having good capacity of fluoride adsorption, highlighting its potential for water **[Rao et al ,(2009)].**

Nitrate: Banana peel can act as an efficient Biosorbent in removal of nitrate from water**.[Suneetha and Ravindhranath, (2012),],** Annona squamosa is commonly known as 'sugar apple' can also be used for the nitrate removal. Calotropis gigantea, commonly known as **madar** (can be found in the compounds of temples), Tridox procumbens (known as Khal-muriya, Tal-muriya in hindi) can also be used as effective bio-adsorbent for nitrate from water **[Suneetha and Ravindhranath, (2012].** Moreover, activated carbon from coconut coir pith, and agricultural solid waste can also be used effectively to remove nitrate from polluted groundwater **[Sumiya U. and Anu (2016)] .** Activated

Carbon Derived from Rice Straw **[Hassan and Sami (2016)]** and 'Chitosan' as an adsorbent, also can remove nitrate**.[Patil et al (2013)],** (adsorbents with positive surface charge are employed which gives more removal efficiency). Activated Carbon prepared from rice husk and sludge of paper industry **[Hasan et al (2015)],** is also an effective measure to remove nitrate. New Clay and Low-Cost Adsorbent natural zeolite **[kumar and Kumar(2011),]** is very useful to remove nitrate.

Arsenic: Arsenic can be removed from drinking water by using some bio-adsorbents such as jute stick powder (JSP), jute leaf powder (JLP), sugarcane powder (SCP), lily leaf powder (LLP), fish ayes powder (FAP), egg's skull (ES), dheki (pteris) vegetable powder (DVP), fern (Dryopteris ramosa) plant powder (FPP **[Islam et al,(2007)].** Moringa oleifera is an effective and alternative biomass for removing As(V) from aqueous solution due to high bio-sorption capacity, easy availability, and being environmentally friendly**.[Sumathi and Alagumuthu, (2007]**

Salinity: Few bio-adsorbent is also effective like **Rangpur lime** are highly **salt-tolerant** root **stock [Ream. and Furr. (1976)] .** Potato has been found as good salt tolerant bio-adsorbent **[. Peechattukudy and . Dhoble ,(2017)].**

VII. CONCLUSION

Groundwater of many areas of Indo-Gangetic plain are severely polluted by various contaminants such as arsenic ,nitrate, fluoride, salinity, etc. Direct consumption of polluted ground water lead to serious damage of human health which is serious matter of concern. Mechanism of presence of pollutants in groundwater should be known to the peoples which may be anthropogenic or geogenic. Currently available techniques to remove contaminants from groundwater have their own merits and demerits. The available technologies used to provide the pure and safe water for the drinking purposes have few drawbacks and mainly the rural people are not able to use these technologies as they are not very cost effective and require lots of skills for operation and maintenance. In the view of few draw backs of available technologies, the development of a new affordable filter to the rural poor people is highly recommended.

In rural areas of our country there are no problem specific and cost effective filters available, thus few new feasible technology should be developed for them to remove the specific pollutants from ground water of the area. It is proposed that attempts should be made to use the adsorption techniques by using low cost filter media. New filter material may be bio adsorbents as these materials are very effective in the removal of various pollutants like nitrate, fluoride, salinity and arsenic. These adsorbents could be locally available organic or inorganic substances for making domestic filters which will be cost effective and could be easily operated and maintained by the rural poor people.

Reference

[1] A. Saxena, S. Kumar and P. Goel,Source Mineral for the Release of Arsenic in the Groundwater of Karanda Block, Ghazipur District,·Uttar Pradesh *Journal Of Geological Society Of India* , Vol.84, pp.590-596**, (2014)**

[2] Anju Verma , Biswajeet Thakur, Shashwat Katiyar, Dharam Singh and Madhu Rai, Evaluation of ground water quality in Lucknow, Uttar Pradesh using remote sensing and geographic information systems (GIS) , *International Journal of Water Resources and Environmental Engineering* Vol. 5(2), pp. 67-76 , **2013**

[3] C Namasivayam & D Sangeetha Removal and recovery of nitrate from water by $ZnCl_2$ activated carbon from coconut coir pith, an agricultural solid waste *Indian Journal of Chemical Technology* Vol. 12, , pp. 513-521 , **2005**

[4] Dipankar Chakrobarti, Bhaskar Das Mathew and T. Murril Examining India's Groundwater Quality Management,School of Environmental Studies, Jadavpur University, Kolkata, India Environ. Science and technology, Vol. 45, pp 27–33, 2011 .

[5] Dipu Sukumumaran, Chitrelekha S Engupta, Rita Saha, Rakesh Chandra Saxena Ground Water Quality Index Howrah, the Heritage of West Bengal India , *Applied Ecology and Environmental Science* Vol. 3(1), pp 5-10, 2015.

[6] Francisca MM, Patrick CK, Peter GN, Assessment of the Impact of Groundwater Fluoride on Human Health: A Case Study of Makindu District in Kenya. J Earth Sci Clim Change 8: 396, 2015

[7] G. Babu Rao, G. Kalyani, B. Vijaya Saradhi* and Y. Prasanna Kumar ,Removal of Fluoride from Aqueous Solution Using a Waste Material. *Nature Environment and Pollution Technology*. Vol. 8 No. 2: pp. 231-236,2009.

[8] Hassan A Hanafi and Sami M Abdel Azeema , Removal of Nitrate and Nitrite Anions fromWastewater Using Activated Carbon Derived from Rice Straw. *Journal of Environmental & Analytical* ,*Journal of Environmental & Analytical*, Volume 6 • Issue 1 • (1-6), 2016

[9] I.D. Patil, M. Husain, V.R. Rahane , Ground water nitrate removal by using 'Chitosan' as an adsorbent, *International Journal of Modern Engineering Research (IJMER)* Vol.3, Issue.1, pp 346-349, 2013

[10] Jia-Qian Jiang, S. M. Ashekuzzaman, Anlun Jiang, S. M. Sharifuzzaman, and Sayedur Rahman Chowdhury Arsenic Contaminated Groundwater and Its Treatment Options in Bangladesh, *International Journal Environment Resources Public Health* Vol. (10), pp 18–46 , 2012

[11] Joshua Nizel Halder and M. Nazrul Islam ,Water Pollution and its Impact on the Human Health ,JOURNAL OF ENVIRONMENT AND HUMAN ISSN(Print): 2373-8324 ISSN(Online): 2373-8332 DOI: 10.15764/EH.2015.01005 Volume 2, Number 1, January 2015

[12] K. Saravanakumar & R. Ranjith Kumar , Analysis of water quality parameters of groundwater near Ambattur industrial area, Tamil Nadu, India , *Indian Journal of Science and Technology*, Vol. 4 No. 5 , pp (660-662),2011

[13] Lizmol A. Peechattukudy and R.M. Dhoble , Removal of Nitrate from Water by Adsorption -A Review *International Journal of Science Technology & Engineering* ,Volume 3, Issue 09 pp (322-325), 2017
[14] M.C. Shannon and, C.M. Grieve Tolerance of vegetable crops to salinity. *Scientia Horticulture* Vol. 78: pp 5-38., 1999
[15] Mazyar Sharifzadeh Baei, Hossein Esfandian and Arash Azizzadeh Nesheli Removal of nitrate from aqueous solutions in batch systems using activated perlite: an application of response surfaceMethodology . *Asia-Pacific Journal Of Chemical Engineering Asia*- Vol. 11, pp 437–447, (2016).
[16] Mehtab Haseena, Muhammad Faheem Malik, Asma Javed, Sidra Arshad, Nayab Asif, Sharon Zulfiqar and Jaweria Hanif Review Article - Environmental Risk Assessment and Remediation Water pollution and human health., Volume 1, Issue 3, 2017
[17] Mohammad Hassan Shahmoradi Behnoush, Amin Zade, Ali Torabian and Mahdi Seyed Salehi Removal of Nitrate From Ground Water Using Activated Carbon Prepared From Rice Husk and Sludge of Paper Iidustry Waste water Treatment , *ARPN Journal of Engineering and Applied Sciences*, Vol. 10, No. 17, pp 7856-7863, 2015
[18] Mohd. EI Quraidi ,Effective Removal of Nitrates Ions from Aqueous Solution Using New Clay as Potential Low-Cost Adsorbent . *Journal of Encapsulation and Adsorption Sciences*. Vol. . pp178-190, 2015
[19] Mukul Bishnoi and Shalu Arora , Potable groundwater quality in some villages of Haryana, India: Focus on fluoride, Journal of Environmental Biology ,Vol. 28(2) PP (291-294) ,2007
[20] Navin Anand Ingle, Harsh Vardhan Dubey, Navpreet Kaur, Isha Sharma , Defluoridation techniques: Which one to choose, Journal Of Health Research & Review, Volume -1 , Issue , 1, Page : 1-4, 2014
[21] Nohar Singh Dahariya, Shobhana Ramteke, Bharat Lal Sahu and Khageshwar Singh Patel Urban Groundwater Quality in India ,Journal of Environmental Protection, Vol 7, pp 961-971, 2016
[22] Pandey S Water pollution and health, Kathmandu Univ Med J (KUMJ). 2006 Jan-Mar;4(1):128-34. Volume 2, Issue 3, pp 157–166 , 2012,
[23] Piddennavar Renuka, & krishnappa Pushpanjali, Review on Defluoridation Techniques of Water, *The International Journal Of Engineering And Science* , Volume 2 ,Issue 3 ,pp 86-94, 2013
[24] Poornima G. Hiremath, Thomas Theodore Biosorption of Fluoride from Synthetic and Ground Water Using Chlorella vulgaris Immobilized in Calcium Alginate Beads in an Upflow Packed Bed Column. *Periodica Polytechnica Chemical Engineering.* Vol. 61(3), pp. 188-199, 2017
[25] R. A. Mandour, Human health impacts of drinking water (surface and ground) pollution Dakahlyia Governorate, Egypt, Applied Water Science r, Volume 2, Issue 3, pp 157–163, 2012
[26] Ranjit Kumar , Mohammad Ali , Ashok Ghosh, Dr Arun Kumar, Arsenic Contamination Of Groundwater And Human Blood in Vaishali District Of Bihar, INDIA: HEALTH HAZARDS, International Journal of Advanced Research · DOI: 10.21474/IJAR01/5276, 2017
[27] Ravi Kant Dubey, Jakir Hussain, Nishchay Malhotra, Ankur Mehta Ground Water Quality and Water Quality Index of Dwrka District of National Capital of India. *International Journal of Research in Engineering and Technology* Volume: 03. pp 245-252, 2014
[28] Ream, C.L. and Furr J.R. Salt Tolerance of some citrus species, relatives and hybrids Tested as Rootstocks. *J. Amer. Soc. Hort. Sci.* Vol. 101(3). pp265-267, 1976
[29] Report of Indian Institute of Toxicology in 2014
[30] Report of Jal Nigam of Uttar Pradesh in 2005-2008
[31] Report presented by CGWB Faridabad (ministry of water resource) in February 2014
[32] S. Kumar and A. Saxena, Chemical Weathering of the Indo-Gangetic Alluvium with Special Reference to Release of Fluoride in the Groundwater, Unnao District, Uttar Pradesh, *Journal Of Geological Society Of India* , Vol.77 , pp.459-477, 2011
[33] Sanghratna S. Waghmare, and Tanvir Arfin Fluoride Removal from Water by various techniques: Review, IJISET - *International Journal of Innovative Science, Engineering & Technology*, Vol. 2 Issue 9, pp (560-571), 2015
[34] Seid Tiku Mereta Biosorption of fluoride ion from water using the seeds of the cabbage tree (Moringa stenopetala): *African Journal of Environmental Science and Technology*. Vol. 11(1), pp. 1-10, 2017
[35] Hemant W. Khandare Scenario of Nitrate contamination in Groundwater: Its causes and Prevention, *International Journal of ChemTech Research CODEN(USA): IJCRGG* ISSN : 0974-4290 Vol.5, No.4, pp 1921-1926, 2013
[36] Tripathi, Parijat and Ramanathan, A. L. and Kumar, Pankaj and Singh, Anshumali and Bhattacharya, P. and Thunvik, R. and Bundschuh, J. ,Arsenic distribution in the groundwater of the Central Gangetic Plains of Uttar Pradesh, India ,Natural arsenic in groundwaters of Latin America. Arsenic in the Environment, 1. Taylor & Francis (CRC Press), London, United Kingdom, pp. 215 224. ISBN , **2009**
[37] ANJALI VERMA, AMIT KUMAR RAWAT and NANDKISHOR MORE (2014), Extent of Nitrate and Nitrite Pollution in Ground Water of Rural Areas of Lucknow, U.P., India Current World Environment Vol. 9(1), 114-122 , 2014
[38] Mamta Goyal, AND Durga Nath Dhar , STATUS OF IRON AND FLUORIDE POLLUTION IN SOME PARTS OF DISTRICT UNNAO, U.P., INDIA Jr. of Industrial Pollution Control Vol 22 (2) pp 277-284 , 2006
[39] Krishna Kumar Yadava, Neha Gupta, Vinit Kumara, Priya Choudharyb and Shakeel Ahmad KhanGIS-based evaluation of groundwater geochemistry and statistical determination of the fate of contaminants in shallow aquifers

from different functional areas of Agra city, India: levels and spatial distributions Royal Society of Chemistry, 2018, Vol 8,pp(15876-15889), 2018

[40] Hemant W. Khandare Scenario of Nitrate contamination in groundwater :Its causes and Prevention International Journal of ChemTech Research Vol.5, No.4, pp 1921-1926, 2013

[41] M.M. Abu-Zreig1 , Y. Abe and H. Isoda, Study of salt removal with evaporation drainage method Volume 48, 2006 CANADIAN BIOSYSTEMS ENGINEERING, **2006**

[42] M Suneetha and K Ravindhranath, REMOVAL OF NITRATES FROM POLLUTED WATERS USING BIO-ADSORBENTS, Int. J. LifeSc. Bt & Pharm. Res. 2012 K , Vol. 1, No. 3,pp 151-160, 2012

[43] Adisheshu Reddy , N. Prashanthi, P. Hari Babu, Jyoti S Mahale, Banana Peel as a Biosorbent in Removal of Nitrate from Water, International Advanced Research Journal in Science, Engineering and Technology Vol. 2, Issue 10, pp 94-98, 2015

[44] Sumiya U. and Anu, Nitrate Removal from Synthetic Wastewater by using Bio-adsorbent. International Journal of Scientific & Engineering Research, Volume 7, Issue 4, pp 307-309, 2016

[45] Ali Ahmad Aghapour , Sepideh Nemati , Amir Mohammadi , Heshmatollah Nourmoradi , Sima Karimzadeh Nitrate removal from water using alum and ferric chloride: A comparative study of alum and ferric chloride efficiency, Environmental Health Engineering and Management Journal Vol.3(2), pp 69–73, 2016

[46] M. J. Islam , M. R. Hossain , A. Yousuf and M. A. Subhan , REMOVAL OF ARSENIC FROM DRINKING WATER USING BIO-ADSORBENTS , Proc. Pakistan Acad. Sci. Vol. 44(3), pp 157-164, 2007

[47] T. Sumathi and G. AlagumuthuAdsorption Studies for Arsenic Removal Using Activated Moringa oleifera,, International Journal of Chemical Engineering, Article ID 430417, 6 pages ,2007,

[48] C.R. Ramakrishnaiah, C. Sadashivaiah and G. Ranganna Assessment of Water Quality Index for the Groundwater in Tumkur Taluk, Karnataka State, India, *E- Journal of Chemistry*, Vol. 6(2), pp 523-530, 2009