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Research Article

URANIUM EXTRACTION FROM GROUNDWATER AND NUCLEAR PLANT WASTE WATER AROUND MINING AREA USING ZEOLITES

Ragaranjan D.K., *Raghu Babu K. and Shiva Pratap T.
Department of Geology, Y.V. University, Kadapa, A.P.
**Author for Correspondence*

ABSTRACT
Normally groundwater is under chemically reducing conditions with low oxygen levels, in such conditions uranium and other heavy mineral solubility is greatly decreased. But within a zone of Uranium mineralization, the concentration of Uranium is high enough that some of the uranium will be dissolved into the groundwater. In addition to uranium, other minerals like arsenic, molybdenum, cadmium, calcium, and radium 226 will be dissolved. Water maintains the human health and health of the ecosystem. According to the recent studies almost 70% of the water in India has become polluted and the pollutants include domestic sewage at one end and industrial effluents on the other. Leaching and mobility of heavy metallic and non-metallic minerals into the aquifers became most dangerous as most of the rural population living in India depends on ground water for domestic and agriculture use. Mobility studies on heavy mineral deposits reveal that these minerals move long distances in very short periods of time. Unexceptionally the uranium found contaminating the groundwater as well as surface water through effluents of uranium mining area. The present study is taken up in order to extract the dissolved uranium, further, to purify the groundwater and waste water released from the nuclear plants by the application of zeta potential technique and by microporous zeolites as molecular sieves. Zeta potential technique is very recent mineral beneficiation technique of ionic separation where the mineral of interest will be kept in zero potential by the adding NaOH, by which all other gangue minerals get charged and collected at respective ionic beds. Zeolites are crystalline, microporous, hydrated aluminosilicates. Zeolite open-structure framework consists of many interconnected voids of discrete size. The voids of the zeolites are utilized as molecular sieve for the separation of the dissolved uranium. The experiments signify 100% pure uranium.

Key Words: *Uranium, Aquifer, Groundwater, Zeolite, Molecular Sieve*

INTRODUCTION
Studies in the uranium mining areas of India reveal contamination of groundwater by leaching of uranium and through released waste waters (Mishra *et al.,* 2012). Radioactive minerals move long distances in relatively short periods of time through colloids moving with groundwater. This kind of transport is attributed to the nanoparticles of the radioactive minerals of less than 15 nm size (Novikov *et al.,* 2006; Ramen *et al.,* 2012). The oxidation and dissolution of uranium minerals lead to growth of its concentration in hydrothermal as well as meteoric fluids. Under reducing conditions, uranium transport is likely to be measured in fractions of centimeter. Uranium is very reactive element combine readily with Cl^- Na_3^-, SO_4^{2-} and CO_3^{2-}. At pH 7 the uranium form stable complexes with phosphate and carbonate (Lucia *et al.,*). Naturally uranium ions occur in tetravalent and hexavalent state amongst these, hexavalent uranium ions (UO_3) are readily soluble in acidic water (Sarangi *et al.,* 2000). The other minerals occur in the groundwater and surface water of study area are arsenic, molybdenum, cadmium, calcium, and radium 226 (Guru-Pratap *et al.,* 2011).
In the present study microporous zeolites are used as molecular sieves (Yangong Zheng *et al.,* 2012) for the separation of gangue minerals from ferric iron oxide uranium carriers. Two different sizes of 15 nm and 3.3 ^{0}A pore size sieves are utilize in two stages for the separation of ferric iron oxide in the first stage and water in the second stage of the process. Zeta potential technique is most recent and better technique that can be used for ore beneficiation (Raghu *et al.,* 2013), where selective minerals are kept at zero

Research Article

potential by the addition of catalyst such as NaOH, at this point of pH, other gangue minerals will attain respective ionic charge, and hence they will be trapped in respective ionic beds.

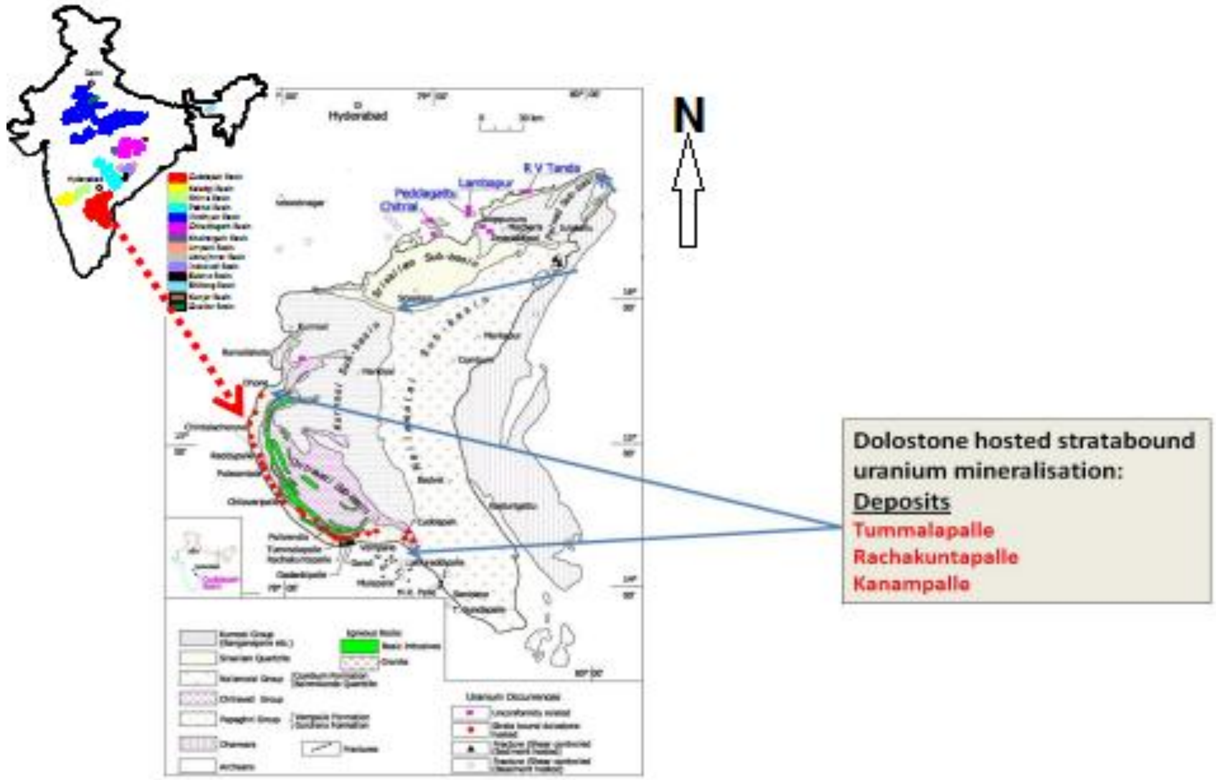

Figure 1: Uranium mineralization in study area

Tummalapalle of YSR District, Andhra Pradesh covered under Survey of India Toposheet Nos. 57 J/3 and 57 J/7 between latitudes 14°18'36" N & 14°20'20" N and longitudes 78°15'16" E & 78°18' 03.3" E. The deposit in the study area is dolostone hosted stratabound type formed by the leaching of uranium from underlying basement granites. The rock type belongs to the Vempalli formation of Cuddapah Supergroup. Tummalapalle project area measures 973 ha (Figure 1).

MATERIALS AND METHODS

Methodology

The radionuclides are immobile in nature, but can be moved great distances through thermodynamic carriers like ferric iron oxide nanoparticles of less than 15 nm size (Novikov *et al.*, 2006; Ramen *et al.*, 2012). In the beneficiation process the water sample collected from groundwater/surface water/uranium mine effluents in and around Tummalapalli Uranium mining area are subjected preliminary processing by passing through bar screen and sediment settling tank. Then the solution is sent through synthesized EMT zeolite molecular sieve of 15 nm pore size. In these process nanoparticles having molecular size more than 15 nm will be separated and sent out. The radioactive mineral along with carrier ferric oxide having 15 nm size that will pass through the zeolite molecular sieve and collected in pH conditioner. In the second stage of treatment the nano ferric oxide along with radioactive mineral with remaining impurities in aqueous solution is kept at zeta potential of uranium by attaining a pH of 5.8 (Wazne *et al.*, 2004; Joseph *et al.*, 1998) by adding NaOH to the solution where the charge of Uranium will become zero while other heavy minerals get charged (Raghu *et al.*, 2013). Then the solution is passed through the ionic beds. The dissolved impurities having respective charge were hold in relevant ionic bed leaving the zero charged radioactive nano Uranium mineral. Resultant solution contains high concentration of Uranium which in the further process, passed through zeolite molecular sieve of 3.3 ^{0}A pore size. The molecular size of water molecule is 3.2 ^{0}A, hence water pass through the zeolite sieve leaving the Uranium mineral. It will be collected, dried and sent for packing for different applications.

Flow Chart of the Process

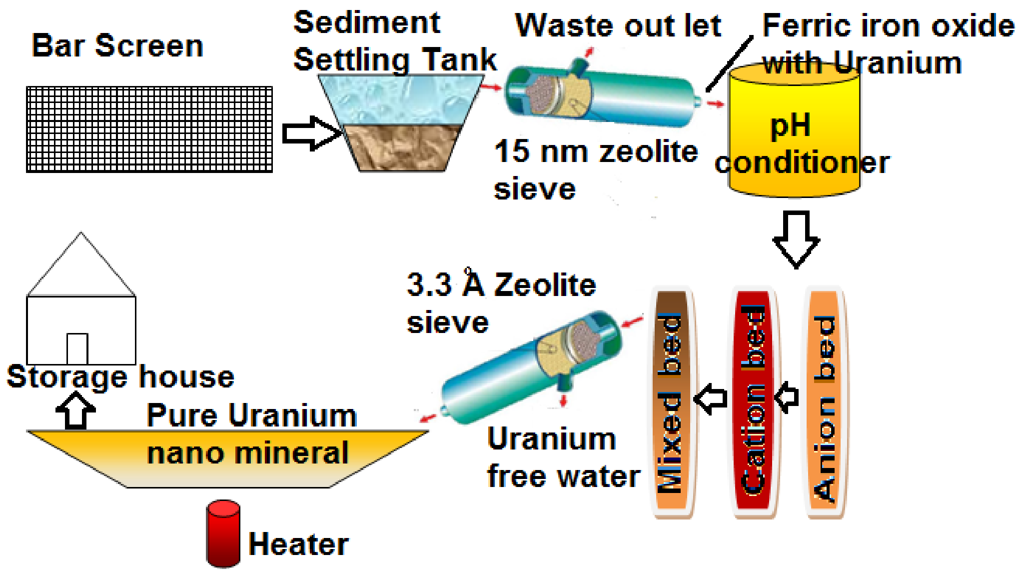

Figure 2: Uranium extraction process

Processing Unit

The processing unit (Figure 2) contain bar screen where higher sized waste material such as wood pieces, paper pieces, cloth pieces, dry leaves, dry sticks etc are removed, and the water enters into sediment settling tank where mud, sand are separated by gravitational settling. Then the solution is passed through the zeolite sieve of 15 nm pore size. Here particles having more than 15 nm size. The ferric iron oxide minerals have a particle size of 15 nm, hence they pass through the zeolite sieve along with radioactive particles and the other gangue minerals having more than 15 nm size are removed. In the following stage the solution is taken into a pH conditioner to maintain a pH of 5.8 by addition of NaOH, which leads to attain zeta potential to radioactive Uranium. In this process the host ferric iron oxide mineral and other gangue minerals will attain ionic nature and trapped in the ionic bed treatment leaving nano sized uranium water solution. This solution is passed through a zeolite sieve of 3.3 ^{0}A pore size. The water molecules have molecular dia of 3.2 ^{0}A are removed through uranium free water outlet (Figure 2). The radioactive nano mineral Uranium is collected into a container and heated gently to make free from moisture and packed for different applications.

RESULTS AND DISCUSSION

The dolostone hosted stratabound Uranium deposit of Tummalapalli area, YSR District is found to have possible solubility in groundwater as well as surface water and mine effluents along with the other heavy minerals. The Uranium mobility in the groundwater is by means of ferric iron oxide of particle size 15 nm. Other heavy minerals dissolved in the ground water of the study area are arsenic, molybdenum, cadmium, cadmium and radium. The Uranium beneficiation process include conventional methods like bar screening, and sediment settling followed by advanced techniques of utilization of zeolite sieves and zeta potential technique. During the process, two types of zeolite sieves of 15 nm and 3.3 ^{0}A pore size are used. Zeta potential technique is an ion exchange process used to hold ferric iron oxide ions which are carriers of Uranium in groundwater. In the ion exchange process the Uranium along with water is collected. The molecular size of water is 3.2 ^{0}A, which is separated by using zeolite molecular sieve of sieve size 3.3 ^{0}A.

Treatment plant should be setup towards the downstream side of either surface water or groundwater so that treatment may take up at the bottom of the water table in the case of ground water or at the basin where the surface waters go stagnant.

Conclusion

In recent decades the Uranium has become an important commodity in the energy sector along with oil, natural gas and coal. Uranium is used primarily in nuclear power reactors for the production of electricity. But the occurrence of uranium in nature in the form of deposit is very rare. It is a known factor that the groundwater and surface water in the Uranium mining area contain dissolved uranium as well as other heavy minerals. Hence to meet the demand, it is essential to consider the quantities of Uranium dissolved in groundwater and surface water around Uranium mining areas. In the present study a technique has been developed and adopted for the beneficiation of Uranium dissolved in groundwater and surface waters around Uranium mining areas. Apart from the beneficiation of Uranium, in the present study, other heavy minerals having economic importance that are collected in different stages can be utilized.

Water purification is the secondary factor in the present study, where water is purified by the removal of all the harmful mineral impurities and highly purified drinking water can be extracted. Environmental safety is the other valuable outcome in the present study.

REFERENCES

Alexander P Novikov, Stepan N Kalmikov, Satoshi Ulsunomiya, Rodney C Eving, Francis Horreald, Alex Merkulor, Sue B Clark, Vladimir V Tkchev, Boris F Myasoedov (2006). Colloid transport of Plutonium in the far field of the Mayak production association, *Science* **314** 638.

Guru Prathap Reddy P and Subba Reddy GV (2011). Physico Chemical Analysis of Surface and Groundwater of Selective Areas of UCIL Tummalapalli Project, YSR (Kadapa), A.P., India, *African Journal of Scientific Research* **3**(1) 163-178.

Joseph N Fiedor, William D Bostick, Robert J Jarabek and James Farrell (1998). Understanding the Mechanism of Uranium Removal from Groundwater by Zero Valent Iron using X-ray photoelectron Spectroscopy. *Environmental Science and Technology* **32**(10) 1466-1473.

Michael F, Hochella, Jr. Steven K Lower, Patricia A, Maurice R Lee Penn, Nita Sahai, Donald L Sparks and Benjamin S Twining (2008). Nanominerals, Mineral Nanoparticles, and Earth Systems, *Science* **319**(21) 1631-1635.

Mishra S, Maity S and Pandit GG (2012). Estimation of distribution coefficient of natural radionuclides in soil around uranium mines and its effect with ionic strength of water. *US National Library of Medicine National Institutes of Health* **152**(1-3) 229-233.

Raghu Babu K and Ragaranjan DK (2013). Electro Kinetic Potential Technique for ore beneficiation of $CaCO_3$, *Journal of Environmental Science, Computer Science and Engineering & Technology* **2**(1) 187-191.

Ramen Sen and Chakrabarti S (2012). Nonoscience persuits in mineral particles and their environmental implications *International Journal of Environmental Science* **2**(3) 2295-2311.

Wazne M, Korfiatis GP and Meng X (2004). Removal of Uranium from Water by Nanocrystalline titanium Dioxide, *Protection and Restoration of the Environment VII – Myknos* Envornomental Applications of Military operations research article.

William R Penrose , Wilfred L Polzer, Edward H Essington, Donald M Nelson and Kent A Orlandini (1990). Mobility of plutonium and americium through a shallow aquifer in a semiarid region, *Environmental Science and Technology* **24**(2) 228-234.

Yangong Zheng, Xiaogan Li and Prabir K Datta (2012). Exploitation of Unique Properties of Zeolites in the Development of Gas Sensors, *Sensors* **12** 5170-5194.