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HYDRO-GEOCHEMISTRY AND HUMAN HEALTH: A BRIEF REVIEW.

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Abstract

The groundwater is of great potential for the fresh water in the perspective of human settlements. The quality of the groundwater for the drinking purpose is certainly the requisite for the human health. The groundwater is mostly affected by the geo-genic sources. These sources make various ions of major and minor in quantity to get dissolved in the groundwater regimes. Certainly, few trace elements are too attributable to the geo-genic sources. In usual case the dissolution does not pose any threat, but on an interference of the external or in situ driving force can disturb the fragile balance of the hydro-geochemistry. In such situations, the ionic concentrations in the groundwater pose a serious threat to the living dependable. The major ions are very obvious in the groundwater but on excess concentration can cause human health issues. The trace metals on the other hand are not typical in the groundwater but, on existence are of severe consequences to the human health. The abandonment of the contaminated groundwater sources is usually advisable but, the thoughtful monitoring of the existing groundwater sources could help the long distant goal in terms of water quality and human health. The present article is a concise review of hydro-geochemistry and human health association.

Keywords – Groundwater, Hydro-geochemistry, Geo-genic sources, Contaminations, Heavy metals.

1. Introduction

The fresh water is an undisputed factor for establishing the settlements of the human kind irrespective to the region and particular location (WHO, 1984; USPHA, 1993). The accustomed source of water for the domestic purpose is an expected aspect for the stability ofany human settlement. The acceptable, harmless and handy resources of the water are obligatory to all life beings, including humans (WHO, 2017). The groundwater is the part andparcel of these resources and has been playing a significant role stability of the human settlements. The groundwater is the major source of fresh water other than riverine and glacial source and is accessible with sufficient ease. The comfort in approachability, also have another end, where the adulteration finds the way in the groundwater resource. Once the groundwater is contaminated by one way or another, it becomes an almost impossible to mitigate the same in any required instance (Mufid al-hadithi, 2012). In such case the water drawn from such contaminated source, creates multiple health issues to human on consumption.

The contamination can occur from the multiple sources, including industrial, domestic, agricultural, geo-genic, etc. (Satapathy *et al.,* 2009; Tiwari *et al.,* 2014). Among them, the present article deals with the review of the geo-genic sources. Such sources contaminate the groundwater in several conditions and are irresistible. The persistence of the geo-genic contaminations is justifiable by the existence of the groundwater in the geology itself (Singh *et al.,* 2020). Hence, understanding the geo-genic causes and there consequenceson human health is the must reviewed issue. The overall study of the groundwater quality in concern with the accompanying geology is termed as the hydro-geochemistry. The interpretation achieved from the hydro-geochemical approach elucidates a lot about the geo- genic

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processes responsible for the water quality and also relates it to the human health (Hem, 1989; Sadashivaiah *et al.,* 2008).

2. Methodology

The portrayal of the influence of the groundwater chemistry, a wide-ranging review of the existing works has been done by considering the furthermost valued works on the platform ofgroundwater chemistry and the human health. The collection of the core concepts from the review, various associations were done with the on-going endeavours on water and human health. The convergence of all the observations was done in the last, to depict an inclusive picture representing the influence of water chemistry on the human health in general.

3. Hydro-geochemistry and Health Hazards

The study of the groundwater chemistry with designated methods of analysis and interpretation along with the elucidation of geo-genic associations can be collectively termed as hydro-geochemistry (Michael, 2014; Ganvir and Guhey, 2022). The hydro-geochemistry basically considers the major and minor ions in the groundwater, but the trace metals including heavy metals are too the indispensible part of it.

3.1 Major ions' chemistry: The major ions in the groundwater includes two bifurcation i.e. cations and anions. In this, the cations represents Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}) and Potassium (K^{+}); whereas, the anions includes bicarbonates (HCO_3^-), Carbonates (CO_3^{2-}), Sulphate (SO_4^{2-}), Chlorine (Cl^-) and Nitrate (NO_3^-). These ions are very obvious with balanced concentration in the groundwater existing in the natural state, without any external interference or action of provoking the ion dissolution. In case of any external interference or situation of aggression, accelerating the dissolution of the ions from the host rock causes the hydro-geochemical disorder. Such disordered hydro-geochemical state of the groundwater obviously makes the groundwater unsuitable for the drinking purpose of human beings.

3.1.1 Source of major ions in groundwater: The major ions in the groundwater are the pure result of the rock-water interaction, if only geo-genic sources are considered (Gibbs, 1970).

a. Calcium (Ca^{2+}): The natural sources of calcium are minerals like feldspar, pyroxene, etc. commonly found in the Igneous and sedimentary rocks. Apart from this, the calcium carbonates rocks i.e. limestone are also the prime contributor. In some cases, the calcium carbonate cementing material of the sedimentary material too aids in calcium dissolution to the groundwater.

b. Magnesium (Mg^{2+}): The usual source of magnesium is accountable to the minerals like minerals like orthoclase, microcline and biotite.

c. Sodium (Na^{+}) and Potassium (K^{+}): The sodium is attributable to the minerals like feldspar, clay minerals, etc. specifically available in the sedimentary rocks, but contribution from other types of rock cannot be underestimated. The existence of potassium is the result of dissolution of the same from the minerals like orthoclase, microcline and biotite, etc.

d. bicarbonates (HCO_3^-), Carbonates (CO_3^{2-}): The chemical weathering including solution and other subsidiary processes of the $CaCO_3$ existing as calcite in igneous rocks, limestone assedimentary rock, etc. are certainly responsible for the bicarbonates and carbonates in the groundwater.

e. Sulphate (SO_4^{2-}): The prime cause of the sulphate in the groundwater is the weathering of the sulphate minerals in the hosting geology. The mineral like pyrite (FeS2) is the most common geological source of sulphate in the groundwater. Apart from this, other sulphate minerals of rare occurrence i.e. chalcopyrite, galena, etc. and industrial sources cannot be denied entirely.

f. Chlorine (Cl^-) and Nitrate (NO_3^-): The solution of the NaCl released from the associated geology could be considered as the key process for the chlorine existence in the groundwater.The sewage seepages too act as point sources for the same, but are of non-geologic origin. The furthermost source of Nitrate in the groundwater is the decaying organic matter, sewage wastes and fertilizers; mostly of non- geologic origin.

3.1.2 Health hazards on ingestion of major ions through water:

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a. Calcium (Ca^{2+}): The high intake of calcium affects directly to the kidney. The condition known as Hypercalcemia can even affect the central nervous system and push towards other serious disorders.

b. Magnesium (Mg^{2+}): *As such there are no serious disorders excluding minors like laxative effect,* nausea, abdominal cramping and diarrhoea.

c. Sodium (Na^{+}) and Potassium (K^{+}): The diseases related to heart like blood pressure, strokes and kidney issues are related to the high sodium intake in one way or another. It also can drive the decalcification. The high intake of potassium causes hyperkalemia resulting into heart shudders, trouble in breathing, chest pain, nausea and vomiting. This can also turn into a life-threatening condition.

d. Sulphate (SO_4^{2-}): The one who has drunk water with high sulphate would suffer from diarrhoea and dehydration issues. The toddlers are at greater risk than the other groups.

e. Chlorine (Cl^-) and Nitrate (NO_3^-): The issues like Stomach-aches, vomiting, and diarrhoea are common, but on overdose can be toxic. The issues related to nitrates are weakness, excess heart rate, fatigue, and dizziness, when took in excess from the drinking water.

3.2 Trace metals' chemistry: The metals including Aluminium (Al), Arsenic (As), Cadmium (Cd), Chromium (Cr), Iron (Fe), Nickel (Ni), Lead (Pb), Zinc (Zn), etc. are some ofthe trace metals existing in the groundwater, but in a very trace amount. These metals are usually stays steady in the host rocks, but on certain set of situation favouring the dissolution and migration add them into the groundwater system, which later poses a serious threat to human beings (Scokart *et al.,* 1983).

3.2.1 Source of few trace metals in groundwater: The usual hydro-geochemical conditions does not prefer the dissolution of the metals in the groundwater, but on the interference of any external or internal drive may causes the enhanced leaching of these metals, which otherwise remains steady (Ganvir and Guhey, 2020 and 2021).

a. Aluminium (Al): The metal aluminium is leading constituent in the rocks consisting mineral like feldspar. The weathered produce of the some other mineral including feldspartoo act as a prime source of the aluminium in the groundwater.

b. Cadmium (Cd): The minerals like sphalerite could be the potential source of the cadmium in the groundwater (Saikia *et al.,* 2009). At some locations, the cadmium is also found to be associated with the carboniferous strata and in sedimentary beds (Satapathy *et al.,* 2009).

c. Iron (Fe): The weathering of the minerals constituting the iron as a part of pyrite is the well-known source of its discharge to groundwater (Chandra, 1992). The other considerable sources are the iron present in the cementing material of sedimentary rocks; rocks like laterite, iron rich stratums, etc. (Finkelman, 1981).

d. Nickel (Ni): The metal nickel is mostly associated with the iron formations and hence, laterite, limonites, pentlandite, etc. are the common sources.

e. Lead (Pb): The common source of the lead in the groundwater is the galena minerals (PbS) usually existing in rare situations. The coal fields have reported thee existence of galena in the geologic sequences possibly causing the dissolution in the groundwater (Finkelman, 1981).

f. Arsenic (As): The common source of arsenic is from the minerals specifically associated with the sulphates and salts in association with multi elements. Some examples are arsenopyrite, realgar, orpiment, arsenolite, etc. The contamination in the groundwater mostly occurs from the soil and sediments containing arsenic.

3.2.2 Health hazards on ingestion of few trace metals through water:

a. Cadmium (Cd): The cadmium compounds are recognized as cancer causing agents by the International Agency for Cancer Research. The toxicity of cadmium includes respiratory disorders, kidney damage, etc. and even damaging the DNA functioning (Mouron *et al.,* 2001; Waisberg, *et al.,* 2003).

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b. Nickel (Ni): It is carcinogenic in nature but in general can cause dermatitis, headaches, gastrointestinal issues, respiratory issues, heart diseases and epigenetic effects (Genchi *et al.,* 2020).

c. Lead (Pb): The lead affects major functions including the central nervous, hematopoietic, hepatic and renal system (Flora, 2009). The indigestion of lead is usually identified by stubborn vomiting, encephalopathy, lethargy, delirium, convulsions and coma. The severest influence of lead is on children's grey matter of brain causing poor IQ (Udedi, 2003).

d. Arsenic (As): The high and elongated exposure of the arsenic through drinking-water could be carcinogenic. The heart issues are also related to it. The undesirable influence on children's' rational behaviour and amplified demises of teenagers are also associated with thearsenic poisoning (Mouron *et al.,* 2001).

4. Remediation

The contaminations in the groundwater are stubborn in nature and it is nearly unmanageable to clear it within a short notice. The best way to avoid the health issues from the contaminated groundwater is to abandon the source for a considerable period of time. The protection of the existing groundwater source through the uninterrupted monitoring is the much needed step, which can also be taken as a remediation through long distant perspective.

5. Conclusion

The groundwater is the prime source of the fresh water but can also act as an agent of health hazards to human beings on contamination with various elements. The hydro-geochemistry precisely studies the chemical condition of the groundwater and relates it with the responsibleprocesses. The associated geology is efficiently linked with the groundwater chemistry and in turn to human health. The endeavour of the hydro-geochemical studies is very crucial in the point of view of human health, especially when the settlements are fully dependent on the groundwater. Though the major ions are an indispensible part of the groundwater chemistry but on excessive dissolution pose a threat to the human health. On contrary, the trace metals are not usual in the groundwater but, on occurrence can cause serious threats to human health. The serious monitoring of the groundwater resources is the best suggested option for securing the quality of it.

References

1. Chandra, D. (1992) Mineral resources of India, 5: Jharia coalfields. J. Geol. Soc. India, Bangalore, v.5, pp.1–149.
2. Flora, S.J.S. (2009) Structural, chemical and biological aspects of antioxidants for strategies against metal and metalloid exposure. Oxidative Medicine and Cellular Longevity, v.2, pp.191–206.
3. Finkelman, R. B. (1981) Modes of occurrence of trace elements in coal. US Geol. Surv.
4. Open-file Rep. Series 81–99, pp.312.
5. Ganvir, P.S. and Guhey, R. (2020) Assessment of some heavy metals toxicity and its probable remediation in groundwater around telwasa and ghugus area of Wardha valley coalfileds, Maharashtra. J Indian Asso. of Sedimentologists, v.37(01), pp.33-43.
6. Ganvir, P.S. and Guhey, R. (2020) Groundwater quality assessment with reference to some heavy metals toxicity and its probable remediation around Ballarpur area of Wardha valley coalfields, Maharashtra. IOP Conference Series: Earth and Environmental Science, v.597(1), 012001.
7. Ganvir, P.S. and Guhey, R. (2021) Geochemical Studies of some Heavy Metals' Toxicity in Groundwater with their Plausible Sources around Gondwana Supergroup, Wardha valley Coalfields, Maharashtra. Journal Geological Society of India, v.97**,** pp. 1415- 1421.
8. Ganvir, P.S. and Guhey, R. (2022) Hydro-geochemical elucidation and its implications in the Wardha valley coalfields of central India. IOP Conference Series: Earth and Environmental Science, 1032:012015.
9. Genchi, G., Carocci, A., Lauria, G., Sinicropi, M.S. and Catalano, A. (2020) Nickel: Human Health

ISSN PRINT 2319 1775 Online 2320 7876

Research paper **UGC CARE Listed (Group -I) Journal Volume 11, Iss 11, Dec 2022**

and Environmental Toxicology. International journal of environmental research and public health, v.17(3):679.

10. Gibbs, R.J. (1970) Mechanisms Controlling World Water Chemistry. Science, 170:1088- 1090.
11. Hem, J. D. (1989) Study and Interpolation of the chemical characteristics of natural water.
12. Water supply paper 2254, 3rd edn, US Geological Survey, Washington, D.C.
13. Michael, A. (2014). Introduction to Hydrogeochemistry, Environmental Impacts and Management Practices.
14. Mouron, S.A., Golijow, C.D. and Dulout, F.N. (2001) DNA damage by cadmium and arsenic salts assessed by the single cell gel electrophoresis assay. Mutation Research, v.498, pp.47–55.
15. Mufid al-hadithi (2012) Application of water quality index to assess suitability of groundwater quality for drinking purposes in Ratmao –Pathri Rao watershed, Haridwar District. India. Am. J. Sci. Ind. Res., v.3(6), pp.395-402.
16. Sadashivaiah, C., Ramakrishnaiah, C. R. and Ranganna, G. (2008) Hydrochemical Analysis and Evaluation of Groundwater Quality in Tumkur Taluk, Karnataka State India. Int. J. Environ. Res. Public Health, v.5(3), pp.158-164.
17. Saikia, B. K., Goswamee, R. L., Baruah, B. P. and Baruah, R. K. (2009) Occurrence of Some Hazardous Metals in Indian Coals. Coke and Chemistry, v.52, pp. 54-59.
18. Satapathy, D.R., Salve, P.R. and Katpatal, Y.B. (2009) Spatial distribution of metals in ground/surface water in the Chandrapur district (Central India) and their plausible sources. Environmental Geology, v.56, pp.323-1352.
19. Scokart P., Meeus-Verdinne K. and DeBorger R. (1983) Mobility of Heavy Metals inPolluted Soils near Zn Smelters. Water Air Soil Pollut. v.20, pp.451–463.
20. Singh, S., Tignath, S., Deolia, D. K., Jha, M. and Dixit, R. (2020) Geochemical Assessment of Groundwater Quality for its Suitability for Drinking and Irrigation Purpose in Jabalpur, Madhya Pradesh, India. Int. J. Res. in Engineering, Science and Management,v.3(08), pp.130-134.
21. Tiwari A. K., Singh P. K. and Mahato M. K. (2014) GIS-Based Evaluation of Water Quality Index of Groundwater Resources in West Bokaro coalfield, India. Current World Environment, v.9(3), pp.843-850.
22. Udedi, S.S. (2003) From Guinea Worm Scourge to Metal Toxicity in Ebonyi State, Nigeria.
23. Chemistry in Nigeria, v.2(2), pp.13–15.
24. USPHA, (1993) International standards for drinking water, United States Public Health Association, US Govt. Printing Office, Washington DC., p. 75-88.
25. Waisberg, M., Joseph, P., Hale, B. and Beyersmann, D. (2003) Molecular and cellularmechanisms of cadmium carcinogenesis. Toxicology, v.192, pp.95–117.
26. WHO, (1984) Guidelines for drinking water qualities, World Health Organisation,Washington DC, p. 35-43.
27. WHO, (2017) Guidelines for drinking-water quality: fourth edition incorporating the first addendum, Geneva.