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Review on safety of community water traetment approach

Ogori A.F and Joeguluba Joe Ogori,

School of Vocational Education, Federal college of education kontagora, PMB 39 Niger state

Abstract

The soil contains bio cumulative covalently dative metal ions. Metals and their compounds are often used in industrial processes, and widely distributed in the environment. Due to their extended persistence in biological systems and tendency to sip along, and bio-accumulate as they move down gradients as well as up the food chain, they represent important environmental and occupational hazards. The removal of toxic contaminants from water is one of the most important environmental issues. Developmental efforts are being made all over the world to develop effective, low cost filtration systems for the remediation of toxic metal ions from water to making it save for community consumption and small scale industrial processes and applications.

Key words: Water, Metallic ions, Safety and Treatment

Introduction

Metals are natural components of the environment, however human activities such as mining, industry and agricultural activities have widely distributed these elements in the environment (Niragu, 1979). The presence of metals in groundwater and soils seriously threatens human and animal health, as well as the ecological systems (Babalola et al, 2007). The chemical type of the metal pollutant determines its solubility, mobility, and toxicity in ground-water systems. The chemical form of metals depends on the source of the metal, waste, the soil and ground-water chemistry at the site (Smith et al, 1995). Both surface and groundwater can be polluted with metals from wastewater discharges or by directly contacting metals-contaminated soils, sludge, mining wastes, and debris (Hess et al., 2002). Metal-bearing solids at contaminated sites can originate from a wide variety of sources in the form of airborne emissions, processed solid wastes, sludge or spills (Goyer, 1996). Uncontrolled inputs of metal into the natural environment pose a range of both short- and long-term environmental risks.

Heavy metals which have received the most attention both in terms of sources and effects are those which are considered as essential or toxic and those that show a high geochemical abundance, these include; zinc, iron, copper, molybdenum, lead, mercury and cadmium (Anetor et al, 2002) .Though the toxic effect of heavy metals is a widespread concern worldwide, men have managed to repeatedly poison themselves in history past. The most celebrated case of heavy metal poison is the 1952 outbreak of methyl mercury poisoning, called the Minamata disease. Nowadays heavy metals are abundant in soil, air, and drinking water, as a result of man's increased use of them, and an increased industrialization, agricultural and mining activities.

Though ground water is rarely an important source of lead poisoning, exposure to lead due to consumption of well water has become an important public health issue in Anka local government of Zamfara state wepedia,(2010). In March of 2010 Medicines Sans Frontieres discovered an unusually high death rate especially among children less than five years old in Anka and Bukkyum local government wepedia,(2010).

Following the discovery of the epidemic, an extensive investigation of the problem was carried out by the centre for disease control (CDC), world health organization (WHO), Zamfara state government, national water resources institute of Nigeria (NWRI), and a team from blacksmith institute, found out that the water did not meet world



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health organization and the Nigerian standard for lead limits in drinking water (WHO, 2010). Estimated 10,000 people were affected by the epidemic including children and more at future long term risk.

In communities where drinking water supply contains high levels of Lead, the reduction of mortality and morbidity is the priority. Thus the importance of the removal of contaminating lead from drinking water cannot be overemphasised. In the case of Anka, the decontamination strategy was the removal of contaminated surface soil and its replacement with new clean soil. Since lead run off from soil is thought to be a major source of contamination, clean soil followed by regulation of mining activity was used to remediate lead Wepedia ,(2010). Another approach to this subject is the provision of purification system, for the removal of lead from drinking water. Employing the principles of adsorption filtration technology, adsorption filters for removal of lead can be developed and used for the provision of lead free water to sensitive areas.

Mechanism of toxicological ions

The issue of Lead poisoning in Anka local government of Zamfara is well researched and well established. The lead content of some wells tested were found to be only several micrograms per liter lead above WHO guideline for lead in drinking water Babalola et al, (2007). The content of other wells however were reported to be more than ten times the acceptable lead level of the guide line. Pond and other surface water were reported to contain about twenty times the acceptable limit. The outbreak which was reported in June 2010 was large. Hundreds of children died of this during the outbreak in Kirsra alone About 50 death and 20 still births were reported Wepedia, (2010). With additional, unreported death, and deaths attributed to other causes .In these community it is likely to be over a hundred . Bagega, Sunke, Daretta, Abari, Tunguar daji, tungar and Kisa have all been confirmed to have high levels of lead in well water Wepidia,(2010).

To halt the death toll and reduce health risk, stake holders quickly enact a two stage strategy; first they remediated then treated affected people by chelation therapy Wepedia, (2010). That lead has complete remediation is questionable. Even it has been effective the whole strategy for complete remediation hinges on the discontinuation of all unsafe mining activity and strict adherence to the guidelines. A fresh case lead poisoning due to unsafe lead mining occurred in Daretta after remediation.As long as mining continues in sensitive areas, well and ponds used for drinking water is at risk of becoming polluted with lead Goyer,(1996).Efforts to treat children poisoned by lead and to clean up affected places and people is hampered by the reticence of communities to divulge cases, for fear of a government ban on lucrative illegal gold mining .

The use of iron and manganese in adsorptive filtration of lead and other heavy metals have been established Pulse,(1994). The removal of lead with adsorption technology can be achieved either by biological or by chemical adsorption filtration. This involve the use of chemically synthesised iron and manganese oxide as coats on porous supported media in the removal of heavy metals. The Biological filtration on which the iron and manganese coating on media are naturally developed by the activity of iron and manganese oxidizing microbes in water have been successfully used for the removal of arsenic, lead, cadmium, iron and manganese. If the goal is to remove lead from water via adsorption filters, then it is important to the parameters needed to make an informed decision to be available. The filtration system is based on iron and manganese, it is important that the level of these elements in water be known. Moreover the level of the element in water determines the filtration method most appropriate for the intended purpose. Hence the determination of the amount of iron and manganese is important.

Iron and manganese oxides have been said to have a diverse capacity for the adsorption of toxic trace metals such as lead, cadmium and arsenic from water. Interaction of trace element with pre-existing cations and anions play a crucial role in chemo logical and biological adsorption elements from water. The interaction of ion and adsorption



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media is also important for effective removal of trace element from water. The interaction of anionic arsenic, cationic lead and the adsorption media result in a reduction of the media's ability to remove lead from water. The determination of arsenic is therefore important, as it give a clue as to what kind of filtration method that could best be adopted.

The adsorption edge, the pH range over which the rapid change in sorption capacity occurs, varies among metals, which results in precipitation of different metals over a large range of pH units. Consequently, mixing metal-rich, acidic water with higher pH, metal-poor water may result in dispersion and separation of metals as different metals are adsorbed onto various media over a range of pH values. Cadmium and zinc tend to have adsorption edges at higher pH than iron and copper, and consequently they are likely to be more mobile and more widely dispersed. Adsorption edges also vary with concentration of the complexing agent; thus, increasing concentrations of complexing agent, increases pH of the adsorption edge Bonnin, (1988). The equilibrium between metal speciation, solubility, adsorption and exchange on solid phase sites is intimately connected to solution pH. Determination of pH in this study is also to tell about the effectiveness of the filtration system. Different elements are best removed at different pH.

Filter membranes and suitability as adsorbents

Inorganic adsorbents:

Minerals like Mont morillonite have been used to remove Pb(II) and Cd(II), Kaolinite was used to accumulate Zn(II), Illite to remove Pb(II), Bentonite was used to adsorb Cr(VI), Activated red mud was used to trap Ni(II) and Cr(II)and Oxidized anthracite was used for the removal of Cd, Cu and Pb. Natural clay and soils and industrial wastes like red mud, aluminium, plant and Mn nodule leaches residue . Low grade ores form another important category of low cost adsorbents. Other adsorbent are activated carbon which has been used for the removal of heavy metals including Pb, especially when it is associated with organic particulate matter in water Smith,(1981). Hydroxides of Alumina, Iron and oxides of iron and manganese are been used as adsorbents for the removal of heavy metals.

Organic adsorbents:

A large number of waste materials of organic origin like dead leaves of trees, bark, roots, seed shells, oil cakes and saw dust from various plants in the form of powder have been utilized for the removal of heavy metals and their adsorption properties have been explored. In addition to these adsorbents wool, albumin, feathers, waste rubber, hair, waste tealeaves, bagasse, rice husk etc. have also been used as organic non-conventional adsorbents. Exhausted coffee was used to remove Cd(II) and Cr(VI) Chenge ,(1994), Formaldehyde-polymerized peanut skin was used to remove Cd(II) and Pb(II) removal, Untreated sawdust was used to remove Cr(VI) from tannery effluents(Baijpa et al., (1992). Leaf mould was used to remove Cr(VI). Activated carbon from hazelnut shells was used for the adsorption of Co(II) from aqueous solution(Baijpai et al,1999). Activated carbon from coconut coir pith was used for the removal for Cd(II) from aqueous solution.

Biosorbents:

They included biomass of algae fungi, and peat moss etc. The advantages of biosorption are low cost, high efficiency of heavy metal removal from dilute solutions, regeneration and possible metal recovery. Filamentous fungi have been found to possess high potential of accumulating Cu, Ni, Co and uranium in aqueous solutions. It has been reported that the biomass of brown algae of the sargassum family possesses a metal binding capacity superior



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to other organic and inorganic sorbents. Several researchers have concluded that the major mechanism of heavy metal uptake by alga.. However, direct application of living fungal cells as biosorbents for heavy metals is unfavourable due to the resistance of living cells to metal ions.

Microbial filters

Large amounts of bacteria, either stalked species such as *Gallionella ferruginea*, or filamentous ones such as *Leptothrix orhracea* were found present in the backwash sludge and those bacteria were in fact found to be responsible for removing the iron . In addition it was noticed that when iron or manganese was complexed with substances like humric acids, polyphosphates, silica etc., which normally interfered with the ability of physical chemical treatment plants to work, that the bacteria could still remove the metals. It was realized that these bacteria could be used for iron removal in water treatment plants before the water enters the municipal distribution system. Owing to the fact that iron is commonly and also because iron is more readily removed from water biologically, it was the first element for which a biological removal system was develop. However biological systems for the removal of manganese, arsenic and other heavy metal have been developed.

The Manganese (IV) oxides produced through microbial activity, i.e., biogenic Mn oxides or Mn bio oxides, are believed to be the most abundant and highly reactive Mn oxide phases in the environment. They mediate redox reactions with organic and inorganic compounds and sequester a variety of metals. The major pathway for bacterial Mn(II) oxidation is enzymatic, and although bacteria that oxidize Mn(II) are phylogenetically diverse, they require a multi copper oxidase-like enzyme to oxidize Mn(II). The oxidation of Mn(II) to Mn(IV) occurs via a soluble or enzyme-complexed Mn(III) intermediate. The primary Mn(IV) bio oxide formed is a phyllo-manganate most similar to δ -MnO₂ or acid birnessite. Metal sequestration by the Mn biooxides occurs predominantly at vacant layer octahedral sites. The toxicity and bioaccumulation potential of heavy metals has prompted great interest in developing models to describe their transport and fate in aquatic environments. Development of meaningful models for trace metal phase distribution require an understanding of trace metal adsorption onto solid phases and associated bio films, which is a key factor influencing the residence time, bioavailability and effects of toxic metals on organisms in aquatic ecosystems . In addition to the well-established effects of solution chemistry (e.g. pH, ionic strength, metal speciation), trace metal

Mechanism of adsorption of ions by surfaces

Adsorption of an impurity from water on to activated carbon may result from solute hydrophobicity, or it may be caused by a high affinity of the solute. Most systems encountered in waste treatment, adsorption results from a combination of these factors. The solubility of a substance in water is significant: solubility in the sense of the chemical compatibility between the water and the solute. The more hydrophilic a substance the less likely it is to be adsorbed. Conversely, a hydrophobic substance will more likely be adsorbed. In the context of solute affinity for the solid, it is common to distinguish between three types of adsorption. The affinity may be predominantly due to: electrical attraction of the solute to the adsorbent or exchange adsorption, van der Waals attraction and physical or ideal adsorption or and chemical reaction (chemisorptions or chemical adsorption).

Many adsorptions process result from specific interactions between functional groups on the sorbate and the surface of the sorbent. These interactions may be designated as 'specific adsorptions'. It is possible for specific adsorptions to exhibit a large range of binding energies, from values commonly associated with 'physical' adsorption to higher energies associated with 'chemisorption'. The adsorptive interactions of aromatic hydroxyl and nitro-substituted compounds with active carbon, for example, are specific adsorption processes resulting from formation of donor-acceptor complexes with surface carbonyl oxygen groups.



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Adsorption results in the removal of solutes from solution and their concentration at a surface, until the amount of solute remaining in solution is in equilibrium with that at the surface. This equilibrium is described by expressing the amount of solute absorbed per unit weight of adsorbent q , as a function of C , the concentration of solute remaining in solution. However an expression of this type is termed an adsorption isotherm.

Lead

Lead is the number two top twenty lists of the most hazardous heavy metals. It account for most paediatric cases of heavy metal poisoning. It is a soft metal and was used for the manufacture of pipes, drains and soldering material for many year. Before 1940 some houses were painted with lead paint. Chronic exposure to lead resulted from chalking, flanking, dust and wethering occurred in that time. Nowadays, most of the lead produced annually is used in the production of battries. Lead is also used in the production of ammuniton, cable covering, plumbing fuel addtives, PVC plastic, X-ray shelding, crystals, pencils and pesticides.

In the human body lead serves no useful purpose, its presence regardless of the route of exposure may cause toxic effect. Lead toxicity involves fundamental biochemical processes. These include lead's ability to mimic or inhibit. Lead and other metals can also be removed from water by the application of the so called biological adsorptive filtration. In this approach instead of chemically synthesised oxide media, the oxide coating on the media naturally developed by the iron and manganese oxidizing microorganism present in ground water. This method comprises of steps of biological oxidation of iron and manganese forming amorphous manganese and iron oxides which coats the surface of the filter medium. Trace metals including lead may be removed from ground water by combination of physio-chemical and biological sorption processes

Iron and iron oxide

Iron and iron oxide coated sand removes arsenic from water. For instance sand from Ganges River, which presumed is rich in iron coatings, removes arsenite from solution, with a reported capacity of 0.024 mg/g. Removal was found to be pH-dependent, and best from pH 7-9. A simple fixed bed unit was able to treat about 160-190 bed volumes of water containing 1000 $\mu\text{g/L}$ arsenite and 150-165 bed volumes of water with 1000 $\mu\text{g/L}$ arsenate. Flushing with 0.2 N sodium hydroxide regenerates the media. Sand material coated with manganese dioxide instead of iron has been prepared. Since MnO_2 is a good oxidant, this material also removes arsenic from water. In fact, the treated sand was able to remove 80% of a 1 mg/L solution of arsenite within two hours, but slightly less than 70% of an equivalent solution of arsenate.

Manganese oxides

Manganese oxides are typically thought to be the most important scavengers of aqueous trace metals in soils, sediments, rocks and water through their seemingly dominant sorptive behaviour despite the fact that they are much less abundant than iron oxides (Bonnin, (1976); In both cases of Mn and Fe oxides/hydroxides, their reactivity and generally high surface areas make them proficient sorbents of many inorganic cation such as Cu, Pb, Zn, Co and Ni among others Luckey, (1975). Synthetic manganese dioxide and manganese dioxide coated on different materials have been widely studied for heavy metal ion adsorption.

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Ionic ore and oxides deposits in the soil.

Oxidizing filter

Moderate levels of iron and manganese, a combined concentration of up to 15 mg/L can be treated with an oxidizing filter. The filter is usually natural manganese greensand or manufactured zeolite coated with manganese oxide. These substances adsorb dissolved iron and manganese. Synthetic zeolite requires less backwash water and softens water as it removes impurities. The amount of dissolved oxygen in your water which can be determined by field test kits, water treatment companies or water testing laboratories only determines the correct oxidizing filter to use.

Aeration-filtration

High concentrations of iron and manganese can be treated with an aeration/filtration system. In this system, air is pulled in and mixed with the passing stream of water. The air-saturated water then enters a precipitator/aerator vessel where air separates from the water. The water then flows through a filter where various filter media screen out oxidized particles of iron, manganese, and some carbonate or sulphate. Pressure-type aerators are commonly used in household water systems. Backwashing the filter periodically is a very important maintenance step. Aeration is not recommended for water containing iron/manganese bacteria or colloidal organic complexes of iron/manganese because they can clog the aspirator and filters.

Chemical oxidation

High levels of dissolved or oxidized iron and manganese at combined concentrations of up to 25 mg/L can be treated by chemical oxidation. This method is particularly helpful when iron is combined with organic matter or when iron/manganese bacteria are present. The system consists of a small pump that puts an oxidizing chemical into the water while it is still in the well or just before it enters a storage tank. This pump operates whenever the well pump operates. The oxidizing chemical may be chlorine, potassium permanganate or hydrogen peroxide. The chemical must be in the water for at least 20 minutes for oxidation to take place and longer if the water contains colloidal iron/manganese. After solid particles have formed they are then filtered, often with a sand filter. Adding aluminium sulphate (alum) improves filtration by causing larger particles to form. When chlorine is used as the oxidizing agent, excess chlorine remains in the treated water. If the particle filter is made of calcite, sand, anthracite or aluminium silicate, a minimum amount of chlorine should be used to avoid the unpleasant taste that results from excess chlorine. An activated carbon filter will remove excess chlorine, as well as small quantities of iron/manganese particles. Chlorine oxidizes iron best at a pH of 6.5 to 7.5. Chlorine should not be used for high levels of manganese because manganese requires a pH higher than 9.5 for complete oxidation. Potassium permanganate is more effective than chlorine for oxidizing manganese at pH levels higher than 7.5. Potassium permanganate is poisonous and causes skin irritation. There should be no excess potassium permanganate in treated water and the concentrated chemical must be stored in its original container away from children and animals. Using this chemical requires careful calibration, maintenance and monitoring. Raising pH and particle filtration If corroded pipes are the source



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of iron/manganese particles in the water, raising the water's pH and using a sediment filter is the simplest solution to the problem.

Shock treatment and filtration

Shock treatment is the most common method of killing bacteria and chlorine is the chemical most often used in this process. It is almost impossible to kill all the iron and manganese bacteria in a system, so repeated shock treatment and chlorination treatment thereafter could prevent bacteria grow back. If repeated treatments become too time consuming, it can be more efficient to install a continuous application system that injects low levels of liquid chlorine or drops of chlorine pellets into the well automatically. Chlorine rapidly changes dissolved iron to solid iron that will precipitate later. Therefore filtration could remove the precipitate.

Conclusion:

The soil is made up of plenty metal ions that migrate depending on the gradient and relative metal ions. Most of these metal ions are toxic at certain lethality of concentration in water such as lead, arsenic and manganese their toxicological chemistry still remain a puzzle since different filtration approach could be adopted. Community water treatment requires safety; this review had advanced processes and microbial filters that could be modulated to achieve safe drinking water in the villages and at community levels.

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