GROUNDWATER QUALITY AND ITS CONTAMINATION

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Abstract- **Most groundwater originates as meteoric water from precipitation in the form of rain or snow. If it is not lost by evaporation, transpiration or to stream runoff, water from these sources may infiltrate into the ground. The porosity and structure of the ground determine the type of aquifer and underground circulation. On the earth, approximately 3% of the total water is fresh water. Of this groundwater comprise 95%, surface 3.5% and soil moisture 1.5%.**

Groundwater moving through sedimentary rocks and soils may pick up a wide range of compound such as magnesium, calcium and chloride. Some aquifers have high natural concentration of dissolve constituents, such as arsenic, boron, and selenium. Arsenic and other naturally occurring inorganic toxic substances present in groundwater in the region have been linked to a variety of chronic diseases, including cancers, heart diseases, and neurological problems. So numerous drinking water wells throughout Myanmar have been tested for arsenic, relatively little is known about the concentration of other inorganic toxic substances in Myanmar groundwater. In this study, we analyzed samples from 16 drinking water wells (10 in Myingyan city and 6 in nearby Tha Pyay Thar village) for arsenic, born, barium, beryllium, cadmium, cobalt, chromium, copper, fluoride, iron, mercury, manganese, molybdenum, nickel, lead, antimony, selenium, thallium, uranium, vanadium, and zinc. Concentration of arsenic, manganese, fluoride, iron, or uranium exceeded health based reference values in most wells. In addition, any given well usually contained more than one toxic substance at unsafe concentrations. While water testing and well sharing could reduce health risks, none of the wells sampled provide water that is entirely safe with respect to inorganic toxic substances. It is imperative that user of these wells, and users of other wells that have not been tested for multiple inorganic toxic substance throughout the region, be informed of the need for drinking water testing and the health consequences of drinking water contaminated with inorganic toxic substances.

Keyword- Groundwater, Arsenic, Manganese, Drinking wat

I. INTRODUCTION

Initial amounts of water from precipitation on to dry soil are held very tightly as a film on the surface and in the micro pores of soil particles in a belt of soil mixture. At intermediate levels, films of water cover the solid particles, but air is still present in the voids of the soil. This region is called unsaturated zone or zone of aeration, and the water present is vadose water. At lower depth and in presence of adequate amounts of water, all voids are filled to produce a zone of saturation, the upper level of which is the water table. Water present in a zone of saturation is called groundwater.

The porosity and structure of the ground determine the type of aquifer and underground circulation. Groundwater may circulate and be stored in the entire geological stratum: this is the case in porous soils such as sand, sandstone and alluvium. It may circulate and be stored in fissures or faults rocks that are not themselves permeable, like most of volcanic and metamorphic rocks. Water trickles through the rocks and circulates because of localized and dispersed fissures. Compact of large fissures or caverns are typical of limestone.

Groundwater is an important source of water supply. Groundwater is also a major source of industrial, agricultural, drinking and domestic water used. In many important groundwater systems, water quality is deteriorating owing to the pressures of population growth and urban, industrial and agricultural development. In particular, the limited sewerage system coverage in urban areas results in extensive use of the liquid effluent and solid waste disposal. The consequent deterioration of groundwater quality has already had significant health and environmental impacts on large populations and is reducing resource availability.

People are withdrawing water from underground aquifer at a faster rate that it can be replenished. Although immense, world's aquifers are not bottomless and in many areas water levels ate sinking fast. The water in some aquifers is millennia old and lies beneath what are now some of the direst regions on Earth. Although people have drown water from springs and wells since the earliest civilizations, in the past 50 years multiplying populations have needed more food and water and the rate of withdrawal has increased dramatically. In some costal areas so much fresh water has been withdrawn from aquifers that saltwater has started to intrude, turning well water brackish and unusable.

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Groundwater, as part of the hydrological cycle, is a vital but hidden resource. It needs proper monitoring, protection and management to ensure future availability.

The main objective of groundwater quality monitoring is the identifications of groundwater quality problems which include coastal saline intrusion, and man-made point sources and diffuse source contamination. It is necessary to assess the seriousness and impact on health and the environment and the economic losses from groundwater contamination.

II. SOURCES OF GROUNDWATER POLLUTION

Saltwater encroachment associated with over drafting of aquifers or natural leaching from natural occurring deposits are natural sources of groundwater pollution. Most concern over groundwater contamination has centered on pollution associated with human activities. Human groundwater contamination can be related to waste disposal (private sewage disposal systems, land disposal of solid waste, municipal wastewater, wastewater impoundments, land spreading of sludge, brine disposal from the petroleum industry, mine wastes, deep-well disposal of liquid wastes, animal feedlot wastes, radioactive wastes, or not directly related to waste disposal (accidents,

certain agricultural activities, mining, highway deicing, acid rain, improper well construction and maintenances, road salt). The following table shows a list of the potential groundwater contamination sources.

Large quantities of organic compounds are manufactured and used by industries, agricultural and municipalities. These man-made organic compounds are of most concern. The organic compounds occur in nature and may come from natural sources as well as from human activities. In many locations groundwater has been contaminated by chemicals for many decades, though this form of pollution was not recognized as serious environmental problem until the 1980. A brief description of the contamination sources follows.

Groundwater contains some impurities, even if it is unaffected by human activities. The types and concentrations of natural impurities depend on the nature of the geological material through which the groundwater moves and the quality of the recharge water. Groundwater moving through sedimentary rocks and soils may pick up a wide range of compounds such as magnesium, calcium and chlorides. Some aquifers have high natural concentration of dissolved constituents such as arsenic, boron, and selenium. The effect of these natural sources of contamination on groundwater quality depends on the type of contaminant and its concentrations.

Pesticides, fertilizers, herbicides and animal waste are agricultural sources of groundwater contamination. The agricultural contamination sources are varied and numerous: spillage of fertilizers and pesticide during handling, runoff from the loading and washing of pesticide sprayers or other application equipment, using chemicals uphill from or within a few hundred feet of a well. Agricultural land that lacks sufficient drainage is considered by many farmers to be lost income land. So they may install drain tiles or drainage wells to make the land more productive. The drainage well then serves as a direct conduit to groundwater for agricultural wastes which are washed down with the runoff. Storage of agricultural is chemicals near conduits to groundwater, such as open and abandoned wells, sink holes, or surface depressions where ponded water is likely to accumulate. Contamination may also occur when chemicals are stored in uncovered areas, unprotected from wind and rain, or are stored in locations where the groundwater flows from the direction of the chemical storage to the well.

Manufacturing and service industries have high demands for cooling water, processing water and water for cleaning purposes. Groundwater pollution occurs when used water is returned to the hydrological cycle. Modern economic activity requires transportation and storage of material used in manufacturing processing, and construction. Along the way, some of this material can be last through spillage, leakage, or improper handling. The disposal of wastes associated with the above activities contributes to another source of groundwater contamination. Some businesses, usually without access to sewer systems, rely on shallow underground disposal. They use cesspools or dry holes, or send the wastewater into septic tank. Any of these forms of disposal can lead to contamination of underground sources of drinking water. Dry holes and cesspools introduce wastes directly in to the ground. Septic systems cannot treat industrial wastes. Wastewater disposal practices of certain type of businesses, such as automobile service stations, dry cleaners, electrical component or machine manufactures, photo processors, and metal platters or fabricators are of particular concern because the waste they generate is likely to contain toxic chemicals. Other industrial sources of contamination include cleaning off holding tanks or spraying equipment on the open ground, disposing of waste in septic system or dry wells, and storing hazardous materials in uncovered areas or in areas that do not have pads with drains or catchment basins. Underground and above ground storage tanks holding petroleum products, acids , solvents and chemicals can develop leaks from corrosion, defects, improper installation, or mechanical failure of the pipes and fittings. Mining of fuel and non-fuel minerals can create many opportunities for groundwater contamination. The problems stem from the mining process itself, disposal of wastes, and processing of the ores and the wastes it creates.

Residential wastewater systems can be a source of many categories of contaminants, including bacteria, viruses, nitrates from human waste, and organic compounds. Injection wells used for domestic wastewater disposal (septic systems, cesspools, drainage wells for storm water runoff, groundwater recharge wells) are of particular concern to groundwater quality if located close to drinking water wells. Improperly storing or disposing of household chemicals such as paints, synthetic detergents, solvents, oils, medicines, disinfectants, pool chemicals, pesticides, batteries, gasoline and diesel fuel can lead to groundwater contamination. When stored in garages or basements with floor drains, spills and flooding may introduce such contaminants into the groundwater. When thrown in the household trash, the products will eventually be carried into the groundwater because community landfills are not equipped to handle hazardous materials.

Arsenic is a semimetal, or metalloid: its properties between those of metals and those of non-metals. It occurs naturally in the earth and in the seas. It is odourless and tasteless. Arsenic is an element (As) that occurs in the earth's crust rock, soil, all natural sources of exposure, or can be traced to deep water brines used to produce oil and natural gas.

Industrial effluents also contribute arsenic to water in some areas. It is widely thought that naturally occurring arsenic dissolves out of certain rock formation when groundwater levels drop significantly. Surface arsenic-related pollutants enter the groundwater systems by gradually moving with the flow of groundwater from rains, melting of snow, etc. Drinking water, especially groundwater, is a major source of arsenic for most people.

Inorganic arsenic can occur in the environment in several forms but in natural waters, and thus in drinking water. Organic arsenic species, abundant in seafood, are very much less harmful to health, and are readily elimination by the body.

Arsenicosis is a chronic illness resulting from drinking water with high levels of arsenic over along period of time (such as from 5 to 20 years). It is also known as arsenic poisoning. The WHO recommends a limit of 0.01 mg/l of arsenic in drinking water.

Arsenicosis result in various health effects including skin problems, skin cancer, cancers of the bladder, kidney and lung, and diseases of the blood vessels of the legs and feet, and possibly also diabetes, high blood pressure and reproductive disorders. (Anon. No Date).

Zinc is naturally present in water. The average zinc concentration in seawater is 0.6 to 5 ppb. Rivers generally contain between 5 and 10 ppb zinc. Algae contain 20 to 700 ppm, sea fish and shells contain 3 to 25 ppm, oysters contain 100 to 900 ppm and lobsters contain 7 to 50 ppm. The World Health Organization stated a legal limit of 5 mg Zn^{2+}/l.

The most significant zinc ores include sphalerite (ZnS) and smithsonite ($ZnCO_3$).These compounds end up in water on locations where zinc ores are found. About three-question of the total zinc supply is used in metal form. The remainder is applied as various Zinc compound are applied for many different purposes. Zinc chloride is applied for parchment production, Zinc oxide is a constituent of solves, paints and catalysers, Zinc vitriol is applied as a fertilizer, and Zinc bacitracine is applied as a growth stimulant in animal husbandry. The larger part of Zinc in wastewater does not stem from point sources. It stems from larger surface water containing the element. Zinc leaks from Zinc pipes and rain pipes, consequential to circulation of carbon rich water. Car tires containing Zinc and motor oil from Zinc tanks release Zinc compounds on roads. Zinc compounds are present in fungicides and insecticides, and consequently end up in water. When inadequate safety measures are taken, Zinc may be emitted from chemical waste dumps and landfills, or from dredge mortar.

The human body contains approximately 2.3 g Zinc, and Zinc has a dietary value as a trace element. Its functions involve mainly enzymatic process and DNA replication. The human hormone insulin contains Zinc, and it plays an important role in sexual development. Minimum daily intake is 2 to 3 kg, this prevents deficiencies. The human body only absorbs 20 to 40 % of Zinc present in food, consequently many people drink mineral water rich in Zinc. Symptoms of Zinc deficiencies are tastelessness and loss of appetite. Children's immune systems and enzyme systems may be affected. Higher Zinc application appears to protect people form cadmium poisoning. Zinc may also decrease lead absorption. Zinc in the human body is an important characteristic. One may also absorb Zinc overdoses. This does not occur very regularly. Symptoms include nausea, vomiting, dizziness, collies, fevers and diarrhea and mostly occur after intake of 4 to 8 g of Zinc. Intake of 2 g of Zinc Sulphate at once cause acute toxicity leading to stomach aches and vomiting (Anon. No Date).

Magnesium is present is seawater in amounts of about 1300 ppm. After sodium, it is the most commonly found cation in oceans. Rivers contains approximately 4 ppm of magnesium, marine algae 3000 to 20, 000 ppm, and oysters 1200 ppm. Dutch drinking water contains between 1 and 5 mg of magnesium per liter. Magnesium and other alkali earth metals are responsible for water hardness. Water containing large amounts of alkali earth ions is called hard water, and water containing low amounts of these ions is called soft water.

A large number of minerals contains magnesium, for example Dolomite ($CaMg(CO_3)_2$) and Magnesite ($MgCO_3$). Magnesium is washed from rocks and subsequently ends up in water. Magnesium has many different ways. Chemical industries and magnesium to plastics and other materials as a fire protection measure or as a filler. It also ends up in the environment from fertilizer application and from cattle feed. Magnesium sulphate is applied in beer breweries, and magnesium hydroxide is applied as a flocculant in wastewater treatment plants. Magnesium is also a mild laxative. Magnesium alloys are applied in car and plane bodies. Magnesium is a dietary mineral for any organism but insects. It is a central atom of the chlorophyll molecule, and is therefore a requirement for plant photosynthesis. Magnesium cannot only be found in sea-water, but also in rivers and rain water, causing it to naturally spread throughout the environment.

Guideline for magnesium content in drinking water are unlikely, because negative human and animal health effects are not expected. Environmental problems indirectly caused by magnesium in water are caused by applying softeners. As was described earlier, hardness is partially caused by magnesium. Calcium and magnesium ions (particularly calcium) negatively influence cleaning power of detergents, because these form nearly insoluble salts with soap. Consequently, about 40 % softener is added to soap.

Water hardness may differ per region, therefore adding softeners to detergents is unnecessary for regions that only contain soft water. In regions containing hard water higher does of detergent may be applied, in order to add more softener. This causes other substances in detergent to be dosed to high, thereby complicating the wastewater treatment process.

The human body contains about 25 g of magnesium, of which 60 % is present in the bones and 40 % is present in muscles and other tissue. It is a dietary mineral for humans, one of the micro elements that are responsible for membrane function, nerve stimulant transmission, muscle contraction, protein construction and DNA replication. Magnesium is an ingredient of many enzymes. Magnesium and calcium often perform the same function within the human body and are generally antagonistic.

There are no known cases of magnesium poisoning. At large oral doses magnesium may cause vomiting and diarrhea. High doses of magnesium in medicine and food supplements may cause muscle slackening, nerve problems, depressions and personality changes. It is unusual to introduce legal limits for magnesium in drinking water, because there is no scientific evidence of magnesium toxicity. In other compounds for example asbestos, magnesium may be harmful (Anon. No Date).

Manganese is a mineral that naturally occurs in rocks and soil and is a normal constituent of the human diet. It exists in well water in CT (Connecticut) as a naturally occurring groundwater mineral, but may also be present due to underground pollution sources. Manganese may become noticeable in tap water at concentrations greater than 0.05 milligrams per liter of water (mg/l) by imparting a colour, odour, or taste to the water. However, health effects from manganese are not a concern until concentrations are approximately 10 times higher.

The CT Department of Public Health (DPH) recently set a drinking water Action Level (AL) for manganese of 0.5 mg/l to ensure protection against manganese toxicity. This AL is consistent with the World Health Organization guidance level for manganese in drinking water. The CT AL provides guidance for prudent avoidance of manganese concentrations of potential health concern. Local health departments can use the AL in making safe drinking water determinations for new wells, while the homeowner in consultation with local health authorities makes decisions regarding manganese removal from existing wells.

This fact sheet is intended to help individuals who have manganese in their water understand the health risks and evaluate the need for obtaining a water treatment system.

Exposure to high concentrations of manganese over the course of years has been associated with toxicity to the nervous system, producing a syndrome that resembles Parkinsonism. This type of effect may be more likely to occur in the elderly. The new manganese AL is set low enough to ensure that the potential nervous system effect will not occur, even in those who may be more sensitive. Manganese is unlikely to produce other types of toxicity such as cancer or reproductive damage.

Yes, and especially so for bottle-fed infants. Certain baby formulas contain manganese, and if prepared with water that also contains manganese, the infant may get a higher dose than the rest of the family. In addition, young children appear to absorb more manganese than older age groups but excrete less. This adds up to a greater potential for exposure in the very young. Since manganese's effects on the developing nervous system have not been adequately studied, it is especially prudent for pregnant women and young children to have drinking water that is below the manganese AL.

III. Hydrogeology of Myingyan-Ngazum- Mahlaing

The Myingyan-Ngazun-Mahalaing is situated in the center of the dry zone. Historically this area has been hydrogeologically renowned for its high salinity, low groundwater yielding and low success rate in locating potable water suitable for irrigation and human consumption. This is still the case in most of the fractured marine shale and fine sandstone aquifers of the Obogon and Kyaukkok formation and adjacent Irrawaddy Formation aquifers. Acute water shortages for both rural and urban domestic purposes still occur in most parts of this area, especially during the dry season even though emergency groundwater drilling program have taken place. Overall there are poor prospects of intersecting high water yielding, low salinity aquifers. However, with careful hydrogeological assessment, the success rate over time has improved.

There are many large scale river pumping stations for irrigation between Nyaung Oo and Myingyan. Operation problems include river level fluctuations, shifting sand bars, absence of stable banks, widespread floods, high bed load, power availability, lack of water delivery to the channel ends and farmer affordability or willingness to pay. Domestic water supply from the Ayeyarwaddy River also faces additional constraints, including bacteriological and agricultural pollution, turbidity and high cost of treatment. Other surface water sources come from reservoirs, tanks, lakes and ponds.

Arsenic exceedance of 50µg/L in the Ayeyarwaddy river alluvial beneath Myingyan and Yesagyo townships is 2.8 and 1.3 percent respectively.

Table 1. Arsenic in groundwater from Myingyan and Environs

Township (Region)	Total samples	Concentration >10µg/L		Concentration >50µg/L	
		No.	%	No.	%
Yesagyo	20	96	18.4	7	1.3
Myingyan	10	60	9.8	17	2.8
Mahlaing	15	101	20.4	6	1.2
Myaung	10	457	23.6	145	4.6

Table 2. Dissolved Metal content of Groundwater from Myingyan

WHO	10	2400	700	50	1500	2000	400	10	40	30	100	Depth (m)
Metal	As	B	Ba	Cr	F	Fe	Min	Pb	Se	U	V	
					µg/L							
SA	22	130	<10	<10	1500	<100	<5	<1	<5	14	<5	37
SB	2	120	<10	<10	800	<100	<5	<1	<5	18	<5	61
SC	2	30	30	<10	900	<100	<5	<1	<5	13	7	55
SD	1	110	<10	<10	1400	<100	<5	<1	<5	5	6	40
SE	1	59	20	10	1100	1180	14	<1	<5	8	9	55
SF	3	<20	20	30	2000*	<100	<5	<1	7	45*	14	61
SG	2	120	10	<10	900	260	<5	<1	<5	16	<5	35
SH	1	140	20	<10	1100	<100	<5	<1	<5	10	<5	31
SL	2	<20	20	<10	1500*	<100	<5	<1	<5	11	<5	55
SJ	3	170	20	<10	2500*	<100	<5	<1	14	10	7	61
SK	2	<20	20	20	1700*	<100	<5	<1	7	33*	6	46
SI	3	360	<10	<10	3600*	<100	<5	<1	<5	16	<5	55

Table.3 Dissolved Metal Analyses from Tha Pyay Thar villag

WHO	10	2400	700	50	1500	2000	400	10	40	30	100	Depth (m)
Metal	As	B	Ba	Cr	F	Fe	Min	Pb	Se	U	V	
Unit					µg/L							
S1	134*	<20	120	<10	<300	3320*	1140*	<1	<5	<1	<5	18
S2	20*	42	250	<10	300	4160*	390	2	<5	<1	<5	23
S3	14*	62	150	<10	400	1930*	750*	<1	<5	<1	<5	19
S4	46*	<20	60	<10	400	1320*	1580*	<1	<5	<1	<5	20
S5	48*	38	160	<10	<300	1110	1748*	2	<5	<1	<5	15
S6	10	<20	190	<10	<300	3680*	541*	<1	<5	<1	<5	17

Dissolved metal content is not usually analysed. Other locations of high dissolved metal may occur in groundwater of the Myingyan- Ngasun- Taungtha area.

IV. Conclusion

Due to the dominance of brackish to saline groundwater in the Pegu Group and seepage into the down gradient Irrawaddy Formation and alluvium, there is overall poor prospects in obtaining large supplies of low salinity water for irrigation purposes. The total area of potential high groundwater yield and low salinity is less than 20 percent of the Myingyan-Ngazun-Mahlaing area. Heavy groundwater extraction may induce salt water intrusion to the pumping facility was located too close to existing brackish areas.

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