Groundwater Pollution

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1-Abstract

The risk of pollution of groundwater indicates that groundwater may be subject to unacceptable pollution due to human activities. This concept has been developed from the vulnerability of groundwater, which is therefore the most important part of the assessment of the risks of groundwater contamination. Generally, groundwater pollution studies include the scientific understanding of biological, chemical and physical processes which control contaminants fate and movement in the underground environment. High chemical concentration in drinking water can pose a health hazard. Protection measures are actually simpler and less costly than corrective measures for groundwater contamination. The choice of appropriate therapeutic technique depends on site-specific factors and often takes into account clean-up goals based on human health and environmental protection. [1]

2-Introduction

Water is essential for life and for all economic activities. It is used for domestic, industrial and agricultural purposes. Having sufficient water in sufficient quantity and quality contributes to maintaining health. The availability of water of good quality is essential to prevent diseases and to improve the quality of life. The use of water increased due to increasing in human population and activities [2]. Groundwater is one of the important components in development of any area. It is the major potable, agricultural and industrial source of water. In 2003, it was estimated that groundwater holds nearly 50% of the drinking water supply, 40% of the demand for industrial water, and 20% of the water used for irrigation [3]. Globally, more than a third of water used by humans comes from groundwater. In rural areas, the ratio is higher: more than half of all drinking water worldwide is supplied from groundwater [4]. Groundwater pollution can also result from innumerable common practices, such as the use of fertilizers and pesticides as well as disposal of human, animal and agricultural waste [5]. Globally, many researchers have conducted a study on the quality of groundwater and pollution sources affected by the industrial and natural process [6]. This concept has been developed from the vulnerability of groundwater, which is therefore the most important part of the assessment of the risks of groundwater contamination [7, 8]. Quality changes of surface water, such as rivers or lakes, may be due to contamination of groundwater. In the past two decades, awareness of groundwater pollution and contamination has been grown up [9].

3-GROUNDWATER RESOURCES AND ITS BENEFITS

The water volume on earth is practically stable and it is estimated at the height of 1600 × 106 km³ [10] . Part of this quantity is trapped in Earth's mantle and is known as juvenile water or magmatic water. The water covering Earth's surface is estimated at the height of 1,370 × 106 km³ and comprises a water body of 2,700 m thickness, covering a surface of 510 × 106 km²[11] . Seawater represents 97.2% of global water volume and is not subjected to human uses such as irrigation, watering or industrial uses [12] [13]. Additionally, a 2.1% of ice and snow, as well as 0.001% of steam, is also not exploited. This results in 0.6% of the global water quantity that can be used and consumed by humans and which is estimated at the height of 8.2 × 106 km³. Out of

this amount, 12% represents runoff water and lake water resources and the rest (approximately 7.2 × 106 km³) the underground water resources [14] [15] However, almost half of these underground water resources occur at depths below 800 m which makes it difficult to reach, while 0.6% of the underground water represents humidity and other loses. Finally, it is estimated that the available fresh water resources for humans are approximately 0.1 × 106 km³ and 3.0 × 106 km³ of surface and groundwater resources, respectively[16] . These estimations indicate the necessity of preserving fresh water resources availability for all life forms on the planet, due to the significant role of the water itself for the living organisms. Fresh water resources are important not only for humans but for every form of life on Earth. Water resources consumption comprises of underground water (95–96%), surface water such as lakes, rivers etc. (3.5%) and soil moisture (1.5%) [17] . As water scarcity problems occur in many parts of the world, groundwater exploitation appears as the easiest way to cover the increasing water demands. An estimation of the mean water resources consumption in industrialized countries is approximately 315 liters per day for domestic use, personal hygiene, gardening, potable water and cooking uses. Potable water and cooking use represents approximately 8 liters per day which is the most important for survival [18] . Millions of people have died over the last decades due to lack of access to clean potable water. Adding up the use of water resources for urban and rural purposes, and industrial production, it can be estimated that the equivalent available quantity of water resources to each person is approximately 7.5 m³ per day.

4-Types of Groundwater Pollution:

Groundwater contamination scenario can be two types.

Point source.

Nonpoint source

Examples of Point Sources

On-site septic systems

Leaky tanks or pipelines containing hydrocarbons

Leaks or spills at manufacturing facilities

Municipal landfills

Livestock wastes (manure lagoons)

Leaky sewer lines

Spills related to highway or railway accidents

Examples of Non-point Sources

Fertilizers on agricultural land

Pesticides on agricultural land and forests

Contaminants in rain, snow, and atmospheric fallout [19] .

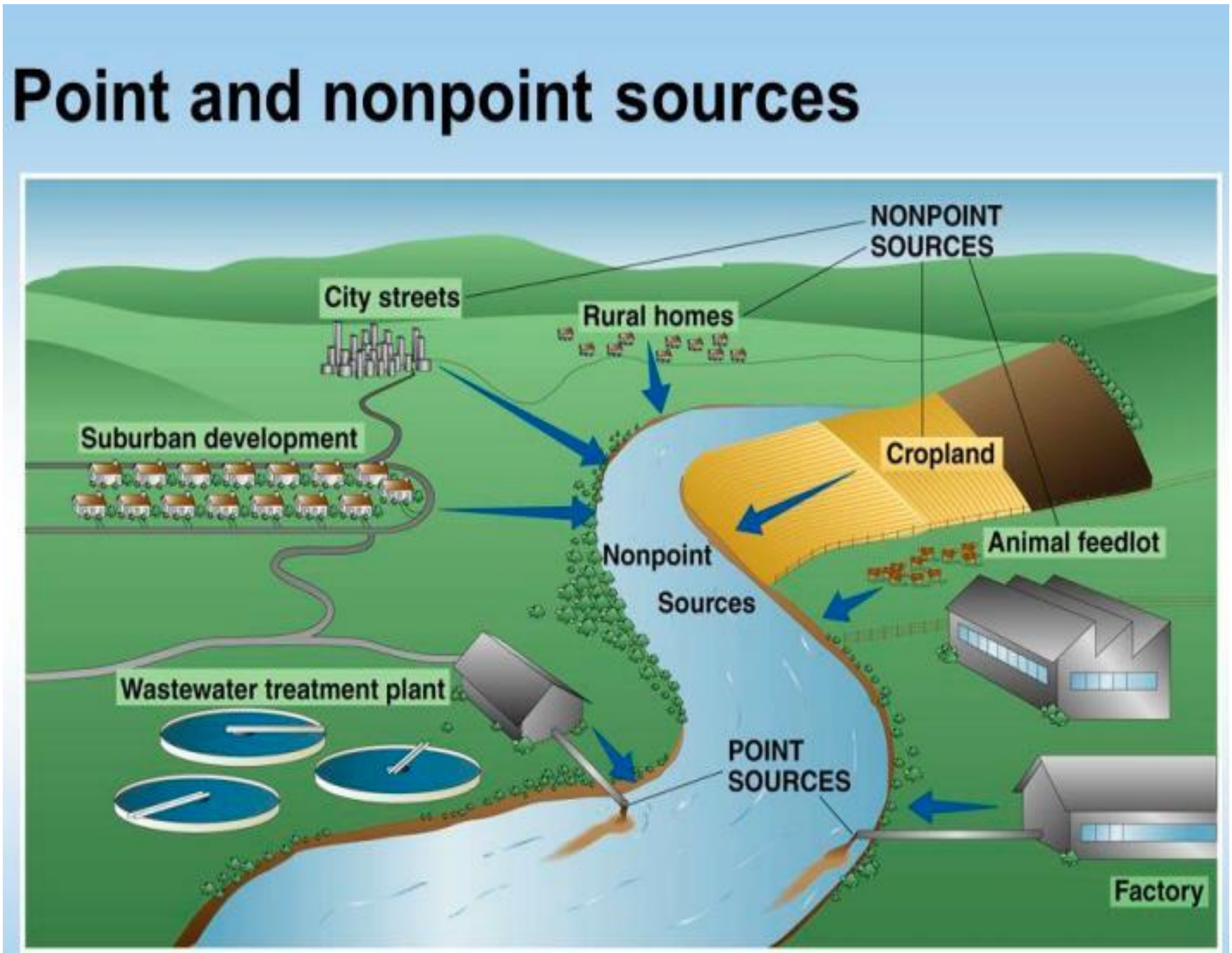


Fig. Point and Nonpoint sources of GWP. Source: www.testech.com

Groundwater is exposed to various sources of pollution due to industrial revolution together with the lack of appreciation of chemicals and their potential impact on land and water bodies. The presence of pollution within groundwater is a major challenge for delineation and identification. Leakage from chemical distribution infrastructure and petrochemicals, for example, pipelines and sewage collection systems such as sewage tanks, urban sewage channels and pipelines are few examples of the real life of unknown underground pollution. Products of mining activities and industrial complexes, which were stored in or underground without any rule to control the contamination of land, was one of the most difficult and difficult problems associated with pollution and management over the last hundred years. The source pollutants characteristics which need to be identified include: - The spatial locations of sources. - The activity duration of sources which clarify the time of sources became active. - The rate of injection of pollutant sources which determines the flow of contaminants from each source [20].

4- 1 Groundwater Nitrate Contamination

: Inorganic contamination of the greatest concern in groundwater is nitrate ions, which usually occur in aquifers near rural and suburban populations. Although uncontaminated groundwater generally has nitrate nitrogen levels of less than 2 ppm, nitrate in groundwater originates mainly from four sources: - Use of nitrogen fertilizers, inorganic and animal manure. - Atmospheric deposition. - Human sewage deposited in septic systems. - Cultivation of the soil [21,22]. Approximately 12 million tones of nitrogen per year are used as fertilizer in agriculture within United States, and the production of manure has contributed about 7 million tones or more. In most cases, nitrogen forms reduction in the soil are oxidized to nitrate, which then migrates to groundwater, where it dissolves in water and it is diluted because nitrate removal from well water is very expensive. Water contaminated with high levels of nitrate normally is not used for human consumption, at least in public-health [23]. The U.S. EPA has established a Maximum Contaminant Level (MCL) of 10 milligrams per liter (mg/L) for nitrate.

Nitrate can affect red blood cells and reduce their ability to carry oxygen to the body. In most adults and children these affected blood cells rapidly return back to normal. however, the blood cells of infants can take much longer to return to normal. As a result, infants who are given water with high levels of nitrate (or foods made with nitrate contaminated water) may develop a serious health condition due to the lack of oxygen. This condition is called methemoglobinemia or “blue baby syndrome

4-2 Acidification

Acidified precipitation is a recognized and widespread phenomenon. The phenomenon of 'acid rain' has been known for over a century and is caused largely by the release of oxides of sulphur and nitrogen into the atmosphere. Acid precipitation effects on groundwater considered to be small. Other sources of acid in groundwater include: interaction of natural water-rock; contamination with industrial acids; and degradation of other contaminants [24].

4-3 Contaminated Land

Contaminated land presents the risk of groundwater contamination if the contaminants are able to migrate to the aquatic environment and continue to have potentially harmful concentrations. The consequences of pollution from human activities in the past and present have led and will continue to lead to serious contamination of groundwater [25, 26]

4- 4 Heavy Metals

In the past there has been a great interest in the fate of heavy metals due to the application of sewage sludge on agricultural land and from landfills. Additional sources of heavy metals include mining and smelting, burning of fossil fuels, metalworking, electronic and chemical industries, war and military training, and the launch of sports. In recent years, the recognition of potential toxic effects and long-term contaminants of heavy metal pollutants has focused on the protection of soil and groundwater [27].

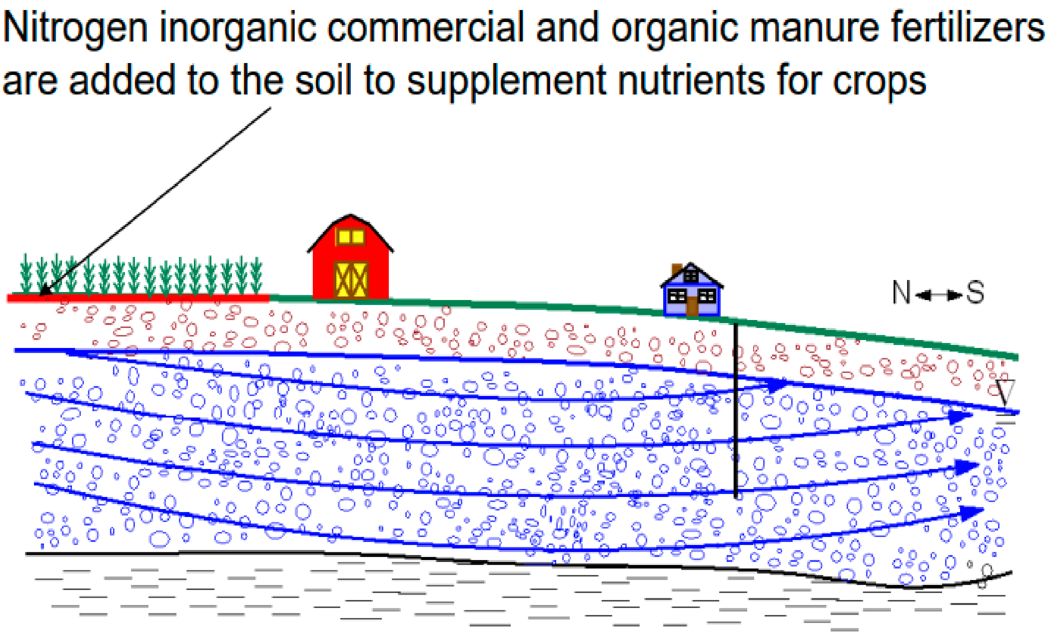
4-5 Landfill

The landfills potential impact on groundwater quality hinges on the continuing debate between 'dilute and disperse' and 'containment' landfill design strategies. Understanding of landfill impact on groundwater requires knowledge of the composition of the landfill leachate. In general, leachate composition depends on the waste type, landfill design and practices, analytical procedures and timing. Most of the foregoing references relate to land filling of mixed household which typically contains a significant organic fraction, is biodegradable and is subject to significant long term consolidation settlement due to low initial density and biodegradation effects. However, certain industrial solid wastes are typically land filled in 'mono-disposal' facilities where only one or possibly two types of waste material are disposed. Examples of these sites are deposits of minerals and mining industry wastes (e.g. colliery shale, coal tailings, quarry fines) and pulverized fuel ash (PFA) from coal-fired power stations. Relatively few references were found on mono-disposal land filling [28]. Pollution of dumpsite (an engineering landfill) identified as a significant threats of groundwater resources [29].

4-6 Microbiological Contaminants

: Microbiological contamination of groundwater is derived from wastewater from humans or animals. The large variety of pathogens that may be present in sewage includes pathogenic bacteria, viruses and protozoa. These contaminants can represent a potentially serious threat to public health if they are present in a water supply. Microbiological contaminants may enter the subterranean environment by leaking sewage, digging sinks, septic tanks, soaking liquids, mines used as a road to disposal, landfills or land-based drainage as fertilizer. The groundwater flow and degree of pollution will be largely subject to the loading of liquid waste and groundwater exposure to surface-derived pollution. Previous studies on the movement of microbiological pollutants in the aquifer environment were more commonly associated with groundwater contamination incidents and to a lesser degree with investigative surveys, both of which concentrated on bacteriological and to a lesser degree on viral contamination [21]. Refuse (domestic and industrial solid waste) is defined as non-useful and undesirable material originating from human activities and not free floating [21]. Poor management of solid materials has led to many catastrophic effects such as aesthetics, environmental hazards and pollution. Groundwater pollution may also occur due to the potential contamination of leachate from waste [29].

4-7 Pollution of groundwater by Nitrate in some pictures:



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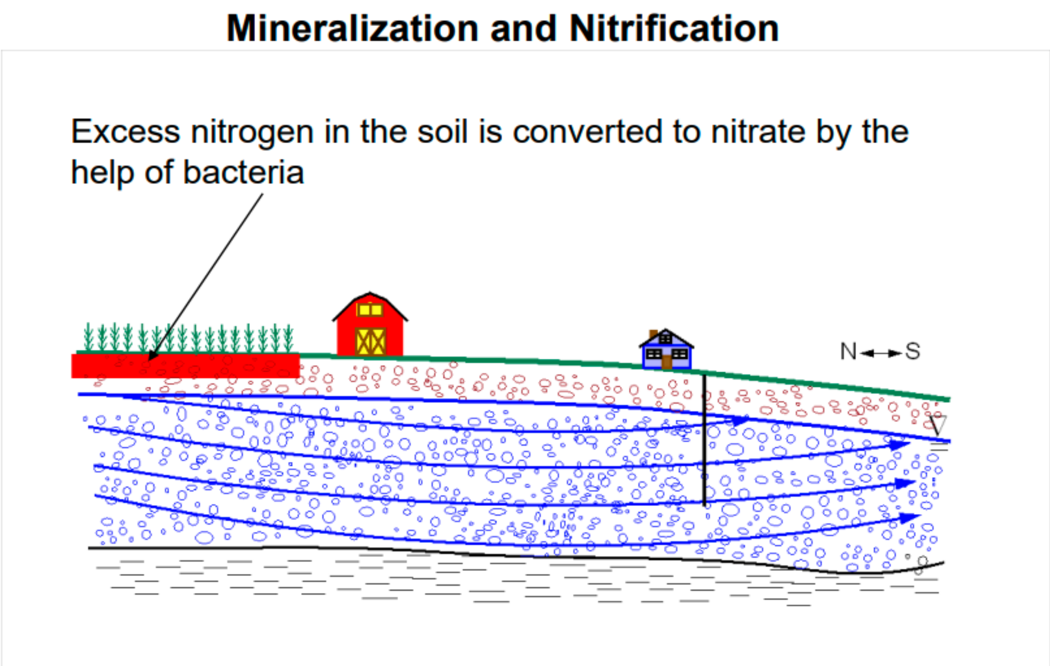

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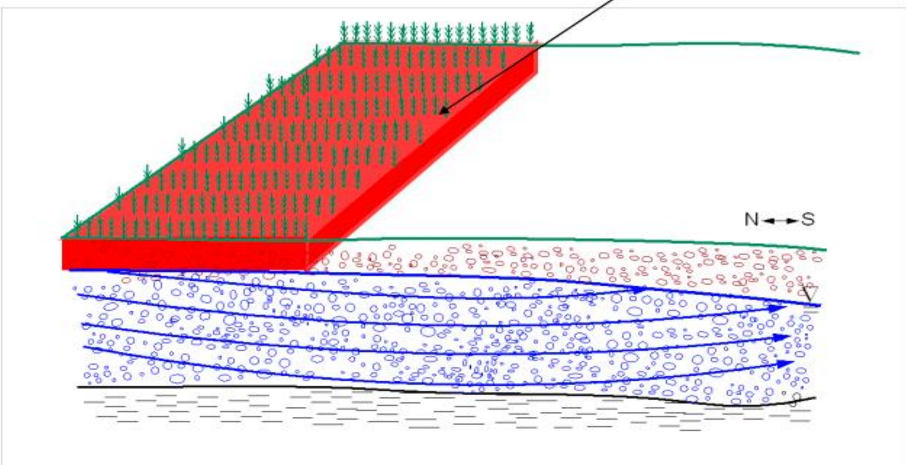
Non-Point Nitrate Contamination

Nitrate derived from fertilized fields is called a “non-point” source contaminant because it covers large surface areas on the aquifer.



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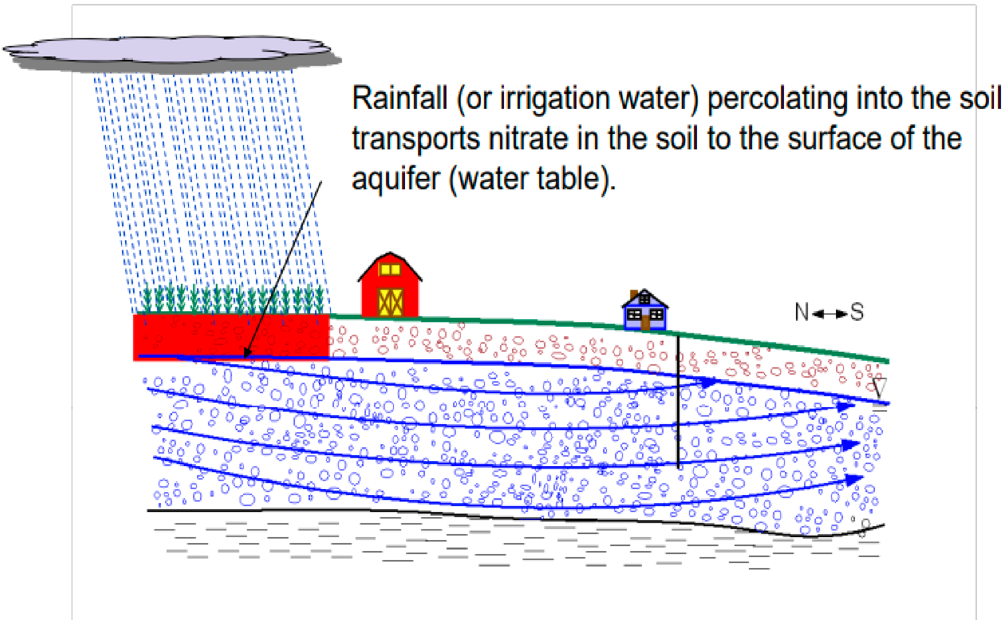
Nitrate Leaching



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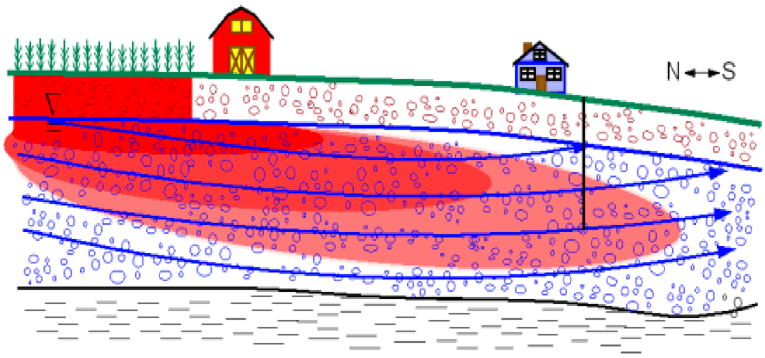
Nitrate is transported through an aquifer by groundwater



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5- Prevention of Groundwater Pollution

Investing in safe drinking water is not only good for personal health and hygiene as well as the environment. It also promotes economic growth. It is therefore necessary to have effective means of preventing groundwater pollution. Prevention of groundwater pollution is the cheapest and most effective solution vis-à-vis remediation [30]. Groundwater pollution can last for years without being detected and by the time it is detected, it must have caused a lot of havoc. Prevention therefore saves tremendous cost. An effective prevention plan should take the following points into consideration: waste disposal, hazardous materials, storm water, management practices, storage tanks and pipelines, small and medium scale business, monitoring wells and water policy formulation. Wastes should be properly disposed. The disposal plan must ensure proper waste water discharge connections and if possible, floor drains should be eliminated. The plan must provide for proper use and maintenance of on-site septic systems. Plug and cover waste dumpsters must be provided. As for the hazardous materials, chemicals and fuels must be safely stored and handled; underground fuels and chemical tanks should be well monitored. Preference should be given to surface tanks which can be monitored more easily. Storage and loading areas are to be controlled while use of chemicals could be reduced or substituted. Prevention of groundwater from pollution through storm water is to protect chemicals and waste from rain and flood penetrating into the aquifers. Drains could be isolated from storage and loading areas while deicing salt and particles should be sparingly used. It is important to conduct environmental audit periodically. This would lead to the development of pollution prevention plan. High risk areas must be regularly inspected while an emergency response plan is developed. Land use plans would need to protect important aquifers and well fields. Residents and businesses must be educated and well informed. Hazardous waste collection must be conducted in all households. All pipelines and storage tanks must be monitored. The right quality of these materials should be procured. Their life span must be noted and they must be replaced at the appropriate time. Those that contain corrosive chemicals should receive special attention. Unused water wells should be properly disposed of. Special attention must be paid to individual, small and medium scale ventures that their activities produce chemical wastes. The level of their financial capability may not enable them to provide adequate preventive measures. The government should come to their aid. Use of insecticides and pesticides should be eliminated or reduced to the barest minimum. This could be done by relying more on waste from livestock. Monitoring wells should be installed at intervals on pipeline network and the vicinity of storage tanks. These would be inspected periodically to ensure early detection of leakages. In addition, the Water Policy formulation should clearly spell out all prevention plans and a body must be tasked to implement the Policy. Awareness measures and penalty should be spelt out and the citizenry should be well informed. [31]

6- CONCLUSIONS

Groundwater resources are vital for human life and health, societal development and the preservation of the natural ecosystems. Today, quality degradation of groundwater bodies represents a major worldwide issue. Various and multiple sources have been identified which include a series of both natural and anthropogenic factors. Human activities such as over abstraction, insufficient wastewater treatment and disposal, industrial activities and use of fertilizers in agriculture represent the main sources of groundwater contaminants. Seawater intrusion is a problem detected in many coastal regions around the world, which results in the salinity and other contaminants increase in coastal groundwater bodies and make them inappropriate for use as drinking water. Radioactivity of uranium series increases radon contamination with significant radon concentration in saturated soils or in groundwater. Groundwater pollution includes a large variety of contaminants, such as organic and inorganic pollutants and synthetic chemical pollutants. The presence of specific groundwater contaminants such as heavy metals, nitrate and emerging contaminants possess significant risks for human health and their regulation is an ongoing issue.

7-References

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