Chapter I

Introduction

Groundwater is vital to life on earth, as it is the world's most abundant source of fresh water. The volume of water on earth is constant. Water circulates between the land, the atmosphere and the oceans in a process known as water cycle. This is a continual global cycle powered by the energy of the sun and the rotation of earth. The water cycle has existed as long as water has been on earth.

Some of the energy from the sun comes to the earth in the form of heat. This heat causes water to become gas or vapour in a process called evaporation. As the surface of earth warms, rising of currents of air carry the vapour upwards. The vapour cools as it rises and forms into tiny droplets, forming clouds. The clouds then fall back to the earth as rain, hail or snow.

Some of the rainfall runs into rivers, streams or wetlands as surface runoff and some evaporates straight back up to the atmosphere. The rest soaks in to the ground and is used by plants, or filters through the soil to become groundwater. Much of the water used by plants returns to the atmosphere as vapour as the heat from the sun removes moisture from the leaves. This process is called transpiration.

Water that finds its way into the groundwater moves slowly towards the nearest river, sea or lake. While many parts of the cycle move fairly rapidly, water that reaches the groundwater can take thousands of years to move slowly underground before evaporation at the surface or transpiration allows it to return to the atmosphere.

Agriculture exists within a symbiosis of land and water. Sustainable development is the management and conservation of the natural resources based on the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs.
for the present and future generations. Such Sustainable development (in the agriculture, forestry and fisheries sectors) conserves land, water, plant and animal genetic resources, is environmentally non-degrading, technically appropriate, economically viable and socially acceptable.

It is well known that agriculture is the single largest user of freshwater resources, using a global average of 70% of all surface water supplies. Except for water lost through evapotranspiration, agricultural water is recycled back to surface water and/or groundwater. However, agriculture is both cause and victim of water pollution. It is a cause through its discharge of pollutants and sediment to surface and/or groundwater, through net loss of soil by poor agricultural practices, and through salinization and water logging of irrigated land. It is a victim through use of wastewater and polluted surface and groundwater which contaminate crops and transmit disease to consumers and farm workers.

Groundwater is one of the major source for water supply in many parts of the country. In India groundwater has played the pivotal role in fulfilling the demands of domestic, industrial and agriculture sectors. At present the groundwater in India contributes more than 58% drinking water, 52% for agriculture production and 50% for urban and industrial sectors. Indiscriminate development and unscientific management of this resource has led to multiple problems of decline in groundwater level, sea water ingress, in –land salinity, groundwater pollution, land subsidence etc.

The measures that need to be adopted in the country to meet the increased water demand in the new millennium would include exploration of deeper aquifers, groundwater recharge, development of aquifer in flood plains, direct use of saline/ brackish water, conjunctive use of surface and groundwater in canal command area, creation of groundwater sanctuaries and regulation of groundwater development.

**The Water Table**

The pores in the unsaturated zone are filled with water and air. Groundwater is the water held in the saturated zone where all the pores are
filled with water. The water table is the boundary between the saturated and unsaturated zone. The water table level moves up and down depending on season recharge and water use.

The water table is the top of the groundwater. It is where soil saturated with water meets drier soil. Swamps and lakes are often forming when the water table reaches the surface of the land in low-lying areas.

Groundwater supplies much of the water used for drinking, irrigation and industry in India. It is one of our most important and precious resources.

**Aquifer**

An aquifer is a layer or area of broken rock or sand that holds a usable amount of water and allows water to pass through it in usable quantities. Water pressure and gravity cause water to move in the aquifer.

**Confined and unconfined aquifer**

There are two types of aquifers, confined and unconfined. A confined aquifer is an area of groundwater that is covered by a layer of intact rock, clay or slit material through which water can not pass. This is known as an impermeable layer. The water in a confined aquifer is held under pressure and when a bore drill through confining layer the water may come in the bore hole and flow out at the top of the bores. These bores are called artesian bores.

Unconfined aquifers have their upper boundary at the earth surface and contain water at the same pressure as surface water, in other words, at atmospheric pressure. They are not constraint by impervious layer of soil and are recharged by the rainfall that filters through the soil from the surface.

**Permeability and Porosity**

The permeability of a soil or rock refers to the rate at which it permits water to move. Lose sandy soils are more permeable than tightly packed fine grained soil like clay or slits. This means that water will pass through lose sandy soils and are recharged by rainfall that filters through the soil from the surface.
Porosity refers to the amount of space in a rock or soil that can store water. Loose grained rock like sandstone are more porous and act more like a sponge to water than compact hard rocks like granite.

The permeability and porosity of a rock and soils help determine the rate of flow in an aquifer and amount of water it can store.

**Contamination**

Groundwater contamination occurs when pollutants (any thing that makes the water unclean and unpleasant) seep through the soil and reach the water table. These pollutants can include pathogens- bacteria or viruses- that threaten the human health, or chemicals such as pesticide, oil or fertilizers. Once contaminated, groundwater can take hundred of years to recover. Contaminated groundwater may be unsuitable for drinking or irrigation to crops and may also cause wetlands and rivers to become toxic to fish, water birds and other life that depends on them.

Groundwater can become contaminated from a wide range of human activities including industrial and commercial developments, the burying of waste, and the over use of agriculture chemical and fertilizers.

There are two kinds of groundwater contamination, point source and diffuse source. Point source contamination results from chemical discharge, spills or leaks at particular sites. The contaminant leaks to the groundwater and surrounding soils and spreads out to form a plume moving in the same direction as the groundwater. The plume may extend several hundred meters or more from the source of the spill or leak.

Diffuse source contamination happen over a wide area such as pollution from the excess use of fertilizers to grow crops. Diffuse source contamination can affect large volume of groundwater.

**Salinity**

Salinity is the measure of how much salt there is in water. It is measured in terms of total dissolve salts (TDS). Fresh drinking water normally has a salt content of less than 500 ppm and is therefore, suitable for drinking and
irrigation. Saline water has high TDS value which means it contains a lot of salts and is useless for drinking and irrigation. When groundwater contains too many dissolved salts it can kill plants and degrade waterways and wetland areas. Land can also be affected by salinity. This happens when the water table – the level of groundwater – rises to the land surface and deposit salts in the top soil, causing the land to become unsuitable for agriculture and killing many native lands.

**Causes of Salinity**

For millions of years salts has been deposited on the land from rainfall. The salt is stored below the surface of the land in the subsoil. When the land is clear the water table rises. This happens for two reasons. Firstly the trees that once remove water from water table are gone. Secondly the pastures and crops planted on the clear land do not use as much as rainfall as the trees they replaced and overtime much of this excess water accumulate as groundwater. When the water table rises it accumulates salts from the soil and causes the groundwater to become saline. Plants whose roots tap in to the saline groundwater die unless they are salt tolerant. In other areas the saline groundwater may rise to the surface of the land damaging soils and degrading wetlands.

**Groundwater Development in India**

During the last five decades, there has been phenomenal increase in growth of groundwater abstraction structures in India. Their number has increased from 4 million in 1951 to about 18 million in 1997-1999, while in the same period irrigation potential created from groundwater has increased from 6 to 30 million hectares.

Commensurate with this growth, groundwater development has been intensive in alluvial area of Indo-Ganga-Yamuna plains of Uttar Pradesh, Uttranchal, Punjab, Haryana and in parts of hard rocks terrain in southern states. Though over exploitation of the resource in some parts of the country has
created serious problems, a large portion of the available resources still remains untapped, particularly in north-eastern areas, where precipitation is high and the demand for irrigation is low and also in eastern states where fragmented nature of land holdings has been a major factor in low development of groundwater.

**Adverse impact of groundwater development**

**Over Exploitation** — In many arid and hard rock areas rapid pace of groundwater development and associated overdraft has resulted in failure of wells and salinity ingress.

**Water Logging** — Large areas in command areas of major irrigation projects suffer from water logging, soil salinity or alkalinity. High intensity of irrigation without adequate drainage has resulted in rapid rise in water table and increased chances of water logging conditions.

**Water Quality Deterioration** — Landward movement of sea water-fresh water interface has resulted into salinity ingress in several areas. Over exploitation of groundwater has also resulted into severe arsenic anomaly reported from West Bengal.

**Steps to resolve groundwater development Constraints** —

- Development of comprehensive information system about the resource base.
- Setting groundwater quality standards reflecting national priorities.
- Establishment of groundwater protected areas by focusing on notification of protected areas for ‘key aquifers’, rather than attempting to protect at once, all groundwater resources.
- Groundwater pollution control by identifying sources and extent of pollution and by strict enforcement of remedial measure.
- Extraction control by setting legal limits on pumping or by motivation for efficient use of groundwater.
- Restriction on subsurface disposal of solid as well as liquid waste.
- Land use regulation by restricting use of chemical fertilizer and pesticides, house density, setup of sewage treatment plants (STPs), under ground storage tanks pipelines etc.
- Conservation and augmentation of groundwater by enhancing the recharge capabilities of the aquifers using site-suitable techniques.

**Occurrence and Movement of Groundwater**

Once water is introduced to the earth as rainfall or snow-melt, it exists in the ground in several different environments. Broadly these environment zones can be classified into two group viz. (a) Zone of Vadose Water (or Unsaturated zone, where all the soil/rock interstices are partly filled with water) and (b) Zone of Phreatic Water (or zone of saturation, where all the soil/rock interstices are fully filled and saturated with water). These two zones are separated by the groundwater table.

**Movement of Groundwater**

Groundwater in its natural state is invariably moving. This movement is governed by established hydraulic principle and can be expressed by Dracy's Law, which states “Flow rate through porous media is proportional to the head loss and inversely proportional to the length of the flow of path”

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Q = \frac{K (h_1 - h_2)}{L}
\]

Where,
- \( Q \) = Specific Discharge
- \( K \) = Hydraulic conductivity
- \( h_1 - h_2 \) = Head loss
- \( L \) = Distance traveled by groundwater
It is generally believed that movement of groundwater follows ground elevation or the general topography of the area.

**Aquifer System**

In term of the potential storage and permeability the aquifers are the most sought-after geological medium in hydro-geological studies. "Water bearing Formation" and 'Groundwater Reservoir' both are synonyms for the word 'Aquifer'. Water cans exist in aquifer under two completely different physical conditions. The most common conditions are when the water table is exposed to the atmosphere through openings in the overlying medium. This type of aquifer is referred to as an unconfined aquifer.

Groundwater may also occur under 'confined condition'. Confined groundwater is isolated from the atmosphere at the point of discharge by impermeable geological formations. The confined aquifer is generally subjected to pressure higher than atmospheric pressure.

In some geological settings, a local zone of saturation may also exist at some level above the regional. The upper surface in such localized zone is called perched water tables and such local water bearing are called 'perched aquifer'.

The importance of groundwater for the existence of human society cannot be overemphasized. Groundwater is the major source of the drinking water in both urban and rural India. Besides, it is an important source of water for the agricultural and the industrial sectors.

The demand for water has increased over the years and this has led to water scarcity in many parts of the world. The situation is aggravated by the problem of water pollution or contamination. India is heading towards a freshwater crisis mainly due to improper management of water resources and environmental degradation, which has led to a lack of access to safe water supply to millions of people. This freshwater crisis is already evident in parts of India, varying in scale and intensity depending mainly on the time of the year.
Groundwater crisis is not the result of natural factors; it has been caused by human actions. During last two decades, the water level in several parts of the country has been falling rapidly due to an increase in extraction. The number of wells drilled for irrigation of both food and cash crops have rapidly and indiscriminately increased. India’s rapidly rising population and changing lifestyles has also indiscriminately increased the domestic need for water. The water requirement for the industry and domestic sectors is driving the groundwater table lower. The quality of groundwater is getting severely affected because of the widespread pollution of surface water. Besides, discharge of untreated waste water through bores and leachate from unscientific disposal of solid wastes also contaminates groundwater, thereby reducing the quality of fresh water resources.

As far as the quality of groundwater is concerned, many states in the country have been identified as endemic to fluorosis due to abundance in naturally occurring fluoride – bearing minerals. These are Andhra Pradesh, Gujarat, Haryana, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Bihar and Delhi. Nearly half million people in India suffer from ailments due to excess of fluoride in drinking water. In some districts of Assam and Orissa, groundwater has high iron content. About 31% of the total area of Rajasthan comes under saline groundwater.

Industrial disposal of effluents on land and subsequent pollution of groundwater and soil of surrounding farmlands is relatively new area of scientific study. Environmental and socio-economic aspect of industrial effluent irrigation have not been studies as extensively as domestic sewage waste irrigation practices, at least for developing countries like India.

With the growing inter and intra sectoral competition for water and declining fresh water resources, the utilization of “Marginal Water Quality” for agriculture has posed new challenges for environmental management. In water scares areas there are competition demands from different sectors on the limited available water sources. Though industrial use of water is very low as compared
to agricultural use, the disposal of industrial effluent on land and or on surface water bodies make water (ground and surface) resources unsuitable for other uses.

The sugar industry in Uttar Pradesh, India is a key factor in the small economy of the state. The growing demand for more sugar factories in all parts of the states is an indication of the importance of the industry to rural development and general economic prosperity. The enormous quantities of wastes (solid, liquid and gas) generated by the industries have laid to the problems of air, water and soil pollution. The Problems of water quality and water pollution are particularly severe in many sugar industrial areas and are threatening the rural population. All types of effluents and most of the by products from any kinds of industry have created most serious problem to the environment. The disposal of such industrial waste is one of the major problems today and will also have to be faced in future with increase adverse effects. Normally, effluents discharged from sugar industries constitute number of chemical pollutants such as carbonate, bicarbonate, nitrite, phosphate and toxic metals in addition to the total suspended solids and other toxicants (Jessudas and Akaliya, 1996). Heavy metal can be determined in different matrix by using various electro-chemical techniques used for the simultaneous determination of heavy metals to trace level.

Water temperature, colour, odour and solids concentrations are physical indicators of water quality. Suspended sediments are common physical contaminants in drinking, irrigation and run of water. Others solids includes organic and dissolved solids. Most sediments occurs because of soil erosion, however, sand may be obtained during from wells.

Chemicals are a major source of water contamination. Some chemical occurs naturally in the water, others are introduced during water movement through geological materials but most of the problems are caused by manufactured chemicals. Fertilizers and pesticides are the major contributors to water pollution by chemical using in agricultures. These chemicals may be
applied to soil or foliage over large areas and hence become potential sources of non-point pollution. However, fertilizer and pesticide have contributed to a high quality and abundant food supply at reasonable cost for the people of the United States and for export.

Nitrates from fertilizers are common chemical pollutant of water. Estimates indicate that U.S. crop land received 10.4 million tones of nitrogen in 1987 from fertilizers (U.S Department of Agriculture, 1988b) and a similar amount through animal manure, crop residue and natural sources. A maximum nitrate concentration to grater 3 mg/ liter was found in 20% of 12.4 wells analyzed over a twenty five years period (Madison & Brunedde, 1985). Concentration greater than 3 mg/liter usually related to human activity such as fertilizers applications, septic systems the federal drinking water standard of mg/liter was exceeded in six percent of samples.

Pesticides include all chemical products used by farmers to control weed, diseases, insects and fungi. In general, insecticides are more harmful to human than herbicides. Pesticides absorb on soil or transported along with sediments in run off water. Forty six pesticides have been detected in groundwater and confirm to come from non-point sources (Williams et. al., 1988). One or more pesticides attributed to agricultural use have been detected in the groundwater of 26 states. The most commonly detected pesticides are atrazine and aldicarb.

Eroded sediments carry attached chemical ions such as phosphorus and potassium, which contribute to chemical pollution as well. These chemicals cause eutrophication in lakes and streams, increased the cost of treatment for domestic and industrial supplies and adversely affect the aquatic lives.

Organic matter and mineralized plant and animal wastes are also significant chemical contaminants of water. Biological decomposition of organic matter in water supplies is often measured by the amount of oxygen needed to complete the decomposition process. Measures of decomposition include Biochemical Oxygen Demand (BOD) and Nitrogenous Oxygen Demand (NOD).
India is vast country and enjoys different types of agro-climatic conditions. In many parts of India water resources has become the most exploited natural system. Due to increasing population growth living standard and industrialization etc., it has resulted into great crisis of good quality of water including surface water as well as groundwater both. In many parts of Indian subcontinent groundwater is not suitable for drinking as well as agricultural purposes mainly because of biological and chemical contamination (Kulkarni, 1990).

The emergence of sugar factories with their allied units in rural areas of the country after 1950 is indication of its pertinence to the rural development (Anand, 1987). In spite of the fact that the sugar industry is the backbone of the rural economy, a need has arisen to review and take in cognizance of other environmental problems associated with it such as water, air and soil pollution. The effluent coming from these industries, some times, percolates through the sub soils to influence nature of streams and riches the ground table forming a contaminated pool which affect natural groundwater quality by changing its chemical composition (Pondhe et. al. 1992). Due to this effect, water pollution in some rural areas spreaded beyond the transitional region, particularly with regard to water cycle. In addition to this, unplanned uses of water for irrigation have also adversely affected the surface as well as groundwater quality. Major source of groundwater pollution in the rural areas is surface percolation of waste water emerging from sugar and its allied units, which affect the water supplies for drinking, livestock and agricultural use.

The water table position plays an important role in the management of soil and crop growth. Israelson (1950) pointed out the even temporary rise of water table adversely affects the crop growth and its yield. Rise in water table has been reported in many canal command areas. According to the observation made water table through different sources in Bhakra canal command area is raising at alarming rate. The water table, which was 20m in 1965 when the canal irrigation was introduced, is now less than 3m a rate of rise of more than one meter every year. In the canal irrigated areas of Pakistan the water table
rose at the rates varying from about 0.15 to 0.60m or more per year due to canal irrigation. Now-a-days it is necessary to examine the water table position and ground condition and existing irrigational resources also.

The groundwater table fluctuates with respect to seasons. It starts growing down from on set of winter and reaches to its maximum depth till the rainfall take place. This down falling of water table is related with rainfall and aridity of the atmosphere. During dry period, the removal of groundwater for irrigation purposes triggered with increased evapotranspiration loss, causes the water table to go down. It starts rising during mansoon and comes very close to the ground surface when sufficient water is accumulated towards the end of rainy season.

In India there is substantial supply available from groundwater sources. About eight lack cubic million rain water that seep into the ground annually about 43% can be utilized by the vegetation in the process evapotranspiration and growth the remaining 60% percolate deeply into the porous strata of the earth crust, representing the grass annual enrichment of under groundwater. This groundwater is tailed by the digging or drilling shallow or deep wells and lifted by using mechanical devices such as tube well, hand pumps, pumping sets for irrigation of crops.

The working group of Planning Commission on the task force groundwater reserves estimated that the usable groundwater potential would be only 75-80% of the net groundwater recharge available and recommended for irrigational purposes.

The present study deals with Studies on Groundwater Pollution near Industrial Areas and Its Irrigational Impact on Some Pulse Crops. In Balrampur there are about 72 small and big industries working in defined industrial area. Out these, Balrampur Chini Mill (BCM) Limited including one sugar mill and distillery in close vicinity. The BCM Ltd. is the largest sugar factory of India by production point of view. The effluent of releasing from these industries and after percolating gets mixed with groundwater which is mainly use for potable
and irrigational proposes to various to various crops and vegetables. The fields are available near the industrial areas which are used for growing vegetables. About 90% growing vegetables in Industrial areas which are irrigated by the effluent mixed groundwater which affect adversely and or prone to susceptible by various disease. Therefore the present study is to see the groundwater qualities near industrial area and its irrigational impact on pulse crops. The main emphasis is give to the mainly to two pulse crops viz. *Cicer arietinum* L. and *Pisum sativum* L.

The findings of the proposed study would be to discuss in the light of available literature and attempt would be made to draw the inference regarding the effect of effluent mixed groundwater on the some pulse crops. The above study may reveal the following facts

1. What are the chief pollutants present in effluent mixed groundwater i.e. how contamination affects (the plant growth) adversely or beneficially?
2. What is the effect of effluent mixed groundwater on seed germination and seedling growth?
3. What is the effect of effluent mixed groundwater on vegetative and reproductive growth with laps of times?
4. What are yield responses of both pulse crops irrigated with effluent mixed groundwater?
5. Whether the effluent mixed groundwater affect the productivity of the plants and causes inhibition in the growth performance and growth behavior?
6. Whether the effluent change the nature and fertility of soil up to some extent.
7. Whether the effluent mixed groundwater is suitable for potable purposes after percolating in the earth crust i.e. suitability for drinking purposes are also assessed.