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INTRODUCTION AND SUMMARY

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Water is absolutely essential for life, not only human but all forms of life, animal and vegetable. Most living cells contain about 80 per cent of water and any substantial reduction in this process is disastrous. The biochemical reactions that are occurring in the metabolism and growth of the living cells involve water and all take place in water. Where there is no water, there is no life. Knowing very well that the root cause of this earth is water, all religions have praised the importance and role of water. Water is associated with many spiritual believes and performances.

Although it has no caloric value, it has got magic effect on the body system. It is known as an universal solvent and get dissolved everything to some extent. Some of the chemical elements or compounds dissolved in its work as essential nutrients in the body and their deficiency causes physical disorders or malfunctions. Iodine, fluoride and other trace metals are a few examples which are most useful for body in micro quantities. Similarly excessive quantities of some of the elements/ions are harmful to the body and cause physiological disorders. Nitrate, Fluoride, Arsenic and Mercury fall in that category.

Water works as a very good medicine to eliminate many disease from the body and hence it is called universal drug. The treatment of diseases making use of water is called Hydrotherapy which is very popular. Water is also important from health point of view, as contamination of water can cause many diseases making the life most miserable. It sustains life but can also take it away if it is not safe and protected. Various diseases and physiological disorders are known to be caused by contaminated drinking water. Presence of any toxic element in water sometimes prove fetal. Millions of children are dying every year due to water borne diseases and billions of people suffer due to various illnesses. Outburst of cholera in London in 1854 and Minamata (mercury poisoning) of Japan in 1957 are the historical incidence indicating the potential hazardous effects of contaminated water on health.

Water can be considered as the most important raw material of civilization since without it man cannot live and industry cannot operate. Wherever a large number of people live together in a community, a supply of potable water is required. History has been shaped by the availability of water. Many civilizations have flourished and ruined due to availability or non-availability of water. The civilization of Indus, Niles and Euftratis are the best examples of it. Water has got multiple uses in the life of human beings and hence water has become an indispensable liquid.

Water possesses many unique properties due to which it has become most useful tool for the survival of life on this earth. Its existence in three forms as water, Ice and Vapour is a rare phenomenon. Its conversion into ice and floating at the surface of water keeps the aquatic life alive in the cold climate. Its hydrogen bonding allows all water take the shape of container. Its capillary action is very useful in plant life to carry water and nutrients through roots to branches and leaves. Although due to its nature to dissolve everything to some extent due to its Universal Solvent property many impurities get dissolved in water. These impurities get access to water during its travel and stay on the earth. Some impurities come as natural and the rest come through the human activities. Dissolution of atmospheric gases, bacteria, particulate matter and humic materials are some of the natural impurities. Turbidity through soil erosion and washing of forest debris are also natural impurities. But man induced impurities involve many aspects. Industrial and domestic wastes causes serious impairment in the quality of water. Any alteration in its natural characteristics interfere with its intended use. Out of all uses, water quality for drinking purpose is of paramount importance. It is therefore essential that quality guidelines and standards are prescribed by concerned authorities. The WHO, Bureau of Indian Standards (Government of India), European community and EPA(USA) are some of the prominent agencies which have formulated drinking water quality standards.

Threat to the human health and environment has increased in recent time due to pollution of water. Indiscriminate discharge of industrial and domestic effluents have polluted the water bodies to such an extent that they have become useless for beneficial uses, besides posing serious concern for health and hygiene.

Pollution of water greatly impairs the uses of water and make them already scarcer water more scarce. It also poses risk to the health and serious threat to the environment and properties. It reduces the carrying capacity of water bodies and rivers. Nature has provided self purification system but is very limited and slow. It is not possible to cope up with the nature's self purification system when the pollution loads are more. Various types of water treatment methods are available to treat the water to required degree. Disinfection of water preferably with chlorination to eliminate the bacterial/biological contamination is widely used method. Similarly coagulation and sedimentation method is used to remove colloidal, suspended and some dissolved (heavy metals) impurities. Sand filters are used to remove suspended and biological impurities. For other specific impurities, advanced methods of water treatment like adsorption, ion-exchange, defluoridation and desalination are used. Due to the complex geohydrological and climatic conditions of Gujarat, the State has got many problems of water quality and quantity. The available water quantity is not safe and acceptable for the intended uses where as the exploding population and rapidly growing industrialisation coupled with urbanisation increases the water demand many fold creating shortage of water. This situation is aggravated by inadequate and uneven rain falls. Drought is a regularly occurring phenomenon here and there and no more perennial rivers. The large area under rocky terrain, largest coastal lines in the country and uncontrolled ground water mining are all worsening the situation.

Due to the above condition, shortage of water is created particularly during summer months. Large number of sources either dries out or turn saline rendering the village without any source known as "No-Source". Due to excessive drawal of under ground water, not only the quality gets depleted but quality also gets deteriorated. Due to sea water intrusion and other factors, the water gets brackish or saline which is not acceptable for domestic and other uses. A situation of water scarcity is created in the drought years or particularly in summer months. The authorities are forced to resort to importing water from other areas to scarcity areas through long distances pipelines or through road/rail tankers. To improve the quality of water for meeting with the drinking water standards, water is sometimes required to desalinate to remove the excessive

dissolved salts content. The scarcity and salinity of water not only hamper the progress and development of people but also many a time forces migration of people.

Fluoride in water is another problem of water faced by the State. Excessive amount of fluoride in water has got severe health hazards and makes the life most miserable. The State of Gujarat is one of the worst affected States in the country, so far as fluoride in drinking water is concerned. Many regions of the State are under the severe effect of high fluoride in water. The authorities are finding it most difficult to provide safe drinking water to the areas where fluoride is high. Wherever possible safe water is brought from other areas through long distance pipeline. In other places defluoridation of water is resorted to. Defluoridation is a chemical treatment of water to remove excessive fluoride through chemical precipitation. Nalgonda method of defluoridation using Alum as Co-agulant is most popular method used in the State.

Nitrates in water is another problem in drinking water encountered by the State. It is a problem mainly with ground waters. Nitrate have got close linkage with health as it causes cyanosis (blue baby) which is also known as methemoglobinemia. It is mostly caused to the infants who consumed more water through milk powder. Nitrates in ground water is coming from ground strata containing minerals, rocks and other natural factors. In addition to that it is also coming from the use of fertilizers in agriculture. The drinking water standards prescribe upper limit of nitrate as 45 mg/l and water having nitrate more than 45 mg/l needs to be rejected for drinking water. Although reduction of nitrate from drinking water is not practiced yet, looking to the trend of increase in water, days are not far off when we will be forced to treat the waters for nitrate removal. Suitable methods are therefore required to be thought of.

In view of the increasing deterioration of drinking water quality coupled with its shortage it was felt highly essential to evaluate drinking water quality in the State of Gujarat. The problems associated with drinking water quality also needed to be examined and discussed. Considering this objectives, the drinking water quality in the State of Gujarat was studied and evaluated in this research project. The quality of water varies from area to area and sometime from season to season. The quality of ground water differs widely from that of surface waters. The ground waters quality based on the local

circumstances and situation, varies widely. All these aspects and implications of deteriorating water quality, are covered in this study.

The second chapter explains the importance of water for the survival and development of mankind. It explains how water is inevitable for various uses within the body and outside. It also explains the use of water in metabolic reactions, for promoting and protecting health, in medicines, in industries, agriculture and many more activities. The ancient civilizations have accorded water, the highest importance by recognising its role in the life. They have praised water by considering it as the gift of water and one of the five basic elements of life. All religions have chanted prayers to God Almighty to bless people with adequate water of good quality. This chapter highlights some of the important couplets from principle religious of the world. The third chapter is on Water and Health which narrates the relation of water with health. Water effects the health of human being in three ways. Firstly, if the essential elements which serve as nutrients in micro quantity are absent than their deficiency causes physiological disorder. Iodine is the best example of it, absence of which causes goitre. There are many such elements/Ions like fluoride and trace metals which are useful for the biological functions of life and their deficiency causes problems. All such possibilities are explained in details. The second aspect is the excessive amount of certain elements/Ions which also causes health hazards. Fluoride and Nitrate are the best examples of it. It has been explained how various elements interfere with health if they are in excess. Similarly health effects of trace metals like mercury and toxic chemicals like pesticides are also explained. The third aspect of water quality and health is regarding the biological/bacteriological contamination and its impacts of health. Although this aspect is outside the scope of this study, a touching reference is made about various water borne diseases and their impacts. This chapter explains the paramount importance of water and its sound bearing on the human health.

Chapter 4 is about water quality and standards which explains various properties of water, the parameters which decide the potability of water and water quality standards prescribed by various agencies. Water is a unique compound on this earth due to its various physical / chemical characteristics. Its existence in three forms as vapour, water

and ice, hydrogen bonding, polar nature, surface tension and universal solvent nature are all making it a unique compound on the earth. Its physical/chemical and biological characteristics decide its suitability for various uses. The guideline values and standards prescribed by various agencies like WHO (World Health Organisation), BIS (Bureau of Indian Standards, Govt of India), EPA (Environmental Protection Agency, USA), EC (European Community) and other agencies are explained. It is also mentioned that Govt. of Gujarat (Gujarat Water Supply & Sewerage Board) which is the principal agency to provide and manage drinking water supply in the rural areas of the State has adopted the standards prescribed by BIS under IS No. 10500/1991.

Chapter 5 gives an account of how water gets polluted and short description about the treatment methods to remove such pollution. This chapter highlights the types of pollutants, their sources, classification and their effects. It further describes the details about surface and ground water pollutants. This chapter also gives in brief the details of water treatment methods. In addition to the conventional methods, some of the special and advanced methods are also indicated.

In the 6th chapter on profile of Gujarat State, the physiography, hydrology and geohydrology of the State are highlighted. Alongwith that, the rainfall pattern, population and the water requirements are also discussed. The industrial development and some of the socio-economical indicators are mentioned which will indicate that the water demand and pollution of water are likely to increase in the years to come. The details on topography, soil types, minerals and aquifer conditions indicate what type of water quality is available in which area. The maps indicating all these aspects are also provided to make the picture more illustrative.

Chapter 7 is on occurrence of salinity in the State of Gujarat. Due to the complex geohydrological conditions of the State and vagaries of weather, the State is facing acute shortage of water. Drought is a regular phenomenon aggravating the situation in many parts making the life most vulnerable and miserable. Large number of people in semi-arid and arid areas are compelled to migrate during summer months. This also has serious impact on the socio-economic aspect of the life of the people. There are no

perennial rivers and large dependence is on ground water sources. This has resulted into over exploitation of ground water resulting into deterioration of quality and quantity both. This has also enhanced the sea water intrusion into the areas near to the sea-coast. The rainfall which is generally inadequate is unable to provide the required recharging of ground water. This has forced to authorities to provide water by importing it from other areas through long distance pipelines. Where this is not possible, the water is supplied through road/rail tankers and desalination is resorted to as a last alternative. In the chapter, the status of No Source Villages and the efforts put in to provide drinking water during scarcity years are narrated. A brief account of desalination techniques adopted and plants installed in the rural areas is also given.

Chapter 8 gives the account of fluoride occurrence in the State and the measures adopted to combat the menace of it. The fluoride problem is mostly occurring in ground waters in Saurashtra and North Gujarat Regions. The adverse effects and the preventive measures are also explained. With that the remedial measures undertaken by the State Authorities are described.

Chapter 9 is about the incidence of nitrates prevalent in the State. Nitrate has got severe health effects, particularly, to the infants. It is an emerging problem in the agriculturally potential areas and is causing serious concern to the Authorities while deciding the potable source of water. Gujarat being a tropical region, the effects of nitrates are getting magnified and are pointed out in this chapter. Although the Authorities are trying to avoid the sources having excessive nitrates, the incidence is on the increasing trend. Unfortunately, there are no economical methods by which nitrate could be removed from the sources having excessive amounts. In the circumstances, the only option left is to go in for alternative sources with optimum amount of nitrates. The study carried out by the author reveals that the public sources of water supply surveyed are not facing any severe problems of excessive nitrates.

To give some idea about the water pollution due to industrial effluents, some case studies on pollution of drinking water are discussed in chapter-10. These studies were carried out under the leadership of the author and are very much relevant with the research work

under this study. The case studies are on pollution of water due to fertilizer factory(GSFC-Dist. Vadodara), Sari Industries at Jetpur(Dist.Rajkot), Fluoride Mines at Kadipani(Dist. Vadodara) and Effluent from Industrial Estates at Ahmedabad. These studies are based on the public complaints received about the pollution of drinking water. The study results reveal that the present drinking water sources are not very much affected by the discharge of effluents from various industries. However constant monitoring of the water quality of all source is essential. Chapter- 11 is on Significance of Parameters. It explains the importance of each parameter covered under the study and also their significance from drinking water quality point of view. Many of the parameters have their importance from health point of view and others are having their impact on the environment and other beneficial uses.

Chapter 12 is on Materials and Methods. It describes the methods used for carrying out the analyses work and also materials used for the same. Water analysis is comparatively a new subject and only limited Government and semi Government organisations are practicing the testing of water. The methods of test are not widely known. "The Standard methods" published jointly by American Water Works Association (AWWA), Water Pollution Control Federation(WPCF) and American Public Health Association(APHA) of USA are widely used for analysis of drinking water. These methods are mostly used for the analysis work. All materials prescribed in the above book of standard quality are used. All analytical grade reagents, corning brand glasswares and watman brand filter papers are used to maintain the high standards of water quality. The methods and instruments used during the study are summarised in a table at the end of the chapter to have its overview at a glance. The methods of sampling and preservation were also used as prescribed in Standard Methods and WHO guidelines. The samples are collected from all types of sources from surface and ground waters.

In chapter 13, the results of the study are discussed. Results of all source samples analysed are tabulated in table No.13.2 and their interpretation is carried out as per BIS Standards prescribed under IS: 10500/1991. The analyses results have revealed that the overall quality of drinking water supplied to the communities all over the State is found

satisfactory. There are three main water quality problems viz. Salinity, Fluoride and Nitrate. The factors contributing to these parameters are discussed. However the authorities supplying drinking water have taken care to avoid the sources having inferior quality. Thanks to the importance given to the quality of drinking water and its continuous monitoring. However due to scarcity of water and exploitation of ground water for agricultural and industrial uses, the quality gets deteriorated particularly from deeper ground strata. The ingress of salinity is observed to a large extent in coastal areas whereas the arid and semi-arid regions are affected by brackishness. The problem of fluorosis is also severe in the State and is discussed separately in chapter No.8. Similarly Nitrate aspect is discussed in chapter No.9. However other aspects of water quality are discussed in chapter No.13. It is heartening to note that the drinking water sources are not affected by the trace elements like cyanide or other significant parameters like Iron and Zinc. During the survey of the areas and interview with the people, it was revealed that there are no serious complaints about the quality of water that they get from the existing sources. Their main complaints were about the quantity and inadequacy of drinking water and not quality. Nevertheless, some areas in North Gujarat particularly Mehsana and Banaskantha and Amreli in Saurashtra have complaints about fluoride in water.

Chapter No.14 indicates possibility of further scopes of research work that could be carried out related to drinking water quality in Gujarat. The author has examined one aspect of physio-chemical quality of drinking water. But there are other areas also like the Bacteriological/Biological quality, Virological quality, Toxicological quality, impacts of deficiency of essential elements or excessiveness of other elements, Industrial pollution and treatment methods for removal of water pollutants. These are some of the important areas which would help understand the quality of water for drinking and other uses.

In chapter 15, a list of papers published by the author is given. It will be seen from the list that the author has published 30 papers so far. Some of the papers are published/presented at international level.. The noteworthy thing is that most of the

papers are related to the topic of this study i.e. quality of drinking water and thus will provide supplementary information on the quality of drinking water of Gujarat.

Thus in this study, the author has tried to examine and evaluate the drinking water quality in the State of Gujarat. This aspect is very much concerned with the people of the State and is one of the basic parameter for their health, well being peace and prosperity. Due to the increasing knowledge and awareness on the aspects of health and hygiene, the water quality consciousness of people is increasing. In view of that, a lot of discussion is taking place and curiosity is raised to know the quality of water that people are drinking. Due to rapid industrialisation and urbanisation also, the quality of water gets deteriorated and suspicious. In view of that, it becomes imperative to know the quality of water. The author has therefore made a humble attempt to investigate the status of prevailing quality of drinking water throughout the State of Gujarat that the people are drinking.