

Water Education for Sustainable Development in Nigeria

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Abstract

Water is one of the natural resources and essentials of life. It occurs abundantly on Earth, covering about 70.9% of the surface, and also in other planets and galaxies. Existing naturally in three different forms (solid, liquid and gaseous), water has been employed extensively in domestic activities as well as in industrial, commercial, agricultural, transportation and tourism sectors of various countries. Water is also a habitat, harbouring a huge variety of plant and animal populations and also contains a lot of mineral reserves. These resources offer a lot of advantages to countries harbouring them and hold the key to future sustainability of life on Earth. However, water has suffered tremendous abuse by man and other agents. Pollution of water through the introduction of organic and inorganic substances and biological agents has affected its physical and physico-chemical properties and rendered it unfit for drinking, harmful to aquatic life and a source of water-borne diseases. The need to control this ugly situation and protect this all important natural resource for sustainable development prompted this research. The work covers the occurrence of water, its properties, pollution and its effects, uses and management of aquatic environment. It is the belief that proper knowledge and understanding of the importance of water and the danger inherent in its mismanagement should make people protect and conserve it for sustainable development of Nigeria in particular and the world in general.

Keywords: *Water, Sustainable Development, Resources, Environment*

Introduction

Sustainable development is a pattern of economic growth in which available resources are used to meet human needs in the present and future generations. Brundt Land Commission as recorded in Wikipedia (2010) defined it as the development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. It involves sustainable use of water, land and other scarce resources, preservation of existing endangered species, and protection of biodiversity. The overall essence of sustainable development is to keep the environment as pristine as naturally possible by making sure that current processes of interactions with the environment restore the previous damaged ecosystem and resist contributing to further ecosystem damage. Sustainable development therefore encompasses attainment of food security, increased per-capita income, enhanced life span, higher agricultural and industrial productivity, continuity of life forms, and higher socio-economic growth in a healthy, sanitary and supportive environment.

Nigeria as a country is endowed with many natural freshwater bodies which include rivers, streams, and lakes as well as ponds, rivulets and spring water. These water bodies are the main sources of drinking water to urban, semi-urban and rural communities in different parts of the country. In most cases, the water bodies are subject to pollution from residential, agricultural and industrial establishments and this limits the supply of portable water for domestic and other desirable uses.

In addition, the water bodies harbor various animal and plant resources as well as mineral and metal resources. Effective exploration and exploitation of the country's aquatic environment and purposeful deployment of the proceeds in areas of road construction, provision of hospitals and other health facilities, building of schools, markets, installation of public utilities and other developmental and welfare projects like establishment of industries will improve the standard of living of the people. In Nigeria, positive on-shore exploration of crude oil, and other natural resources, irrigation, damming, fish farming and aquaculture, hydrology and exploitation of soil and substrate materials like sharp sand and mineral ores have continued to earn substantial revenue and foreign exchange to the country. Effective management of aquatic environment is therefore one of the contributing factors to the attainment of sustainable development in Nigeria.

Occurrence of Water

Water is the most abundant naturally occurring compound prevalent in the universe for nearly its entire existence (Clavin and Bluis, 2012). Apart from the earth where it occupies about 70.9% of the surface, water exists in other planets and galaxies because its components, hydrogen and oxygen are among the most abundant elements in the universe (CIA 2008). On 22 July, 2011 a report described the discovery of a gigantic cloud of water vapour containing 140 trillion times more water than all of earth's oceans combined, around a quasar located 12 billion light years from the earth (Staff, 2011).

As vapour, water is present in the earth's atmosphere and the atmospheres of Mercury, Venus, Mars, Jupiter and Saturn as well as in the Moon of Saturn and exoplanets (Blue, 2007, Messenger Scientists, 2008). Similarly, liquid water occurs in the Earth's surface and Europa which is 100km deep sub-surface ocean and a strong evidence suggests that liquid water is also present just under the surface of Saturn's moon Enceladus (NASA, 2009). In addition, solid form of water (ice) is found on the Earth, mainly as ice-sheet, polar ice caps in Mars, Moon, Titan, Europa, as well as Saturn's ring, Enceladus, Pluto, Charon and Comets (Sparrow, 2006). New scientists (2010) reported that water forms parts of the internal structures of Uranus and Neptune, and in the deeper layers, the water may be in ionic form in which the molecules break down into hydrogen and oxygen ions.

Furthermore, water is also found in the bodies of living organisms and it makes up about 55-78% of human body (CIA, 2008, Jerffery 2008). It is also present, in the food we eat, the beverages we drink and many of the products we use everyday contain it or were manufactured using it (Shanna, 2012). Water can also be released in the body during respiration, as well as in some chemical reactions in the laboratory and other processes like combustion of fuels. However, water cannot be manufactured from its components elements. This is because hydrogen is highly inflammable and oxygen supports combustion, hence any attempt to manufacture water form its constituent elements could lead to explosion (Josh, 2012).

Continuous circulation of water occurs between the atmosphere, surface water, groundwater, plants and animals. This forms the water or hydrologic cycle which refers to the processes that bring about the circulation of water in nature. The features of the water cycle include:

- Evaporation of water from oceans, seas, rivers, streams and other water bodies.

- Transpiration by plants.
- Excretion and perspiration by animals
- Decomposition of dead bodies of plants and animals.
- Precipitation of condensed water vapour from the atmosphere to the Earth and water bodies.
- Runoff of water from the land into water bodies.
- Seepage of rainwater into the soil to form spring water or ground water.
- Absorption of water from the soil by plants.
- Intake of water by drinking and through food by animals.

Despite the abundance of water on the surface of the Earth, the provision of clean drinking water is increasingly becoming an important world issue. For centuries, clean drinking water has been hard to come by, available in some areas but often polluted and disease - ridden while in other areas, it is not available (Josh. 2012).

Properties of Water

As a chemical compound, water possesses some properties which distinguish it from other chemical compounds. It is the only substance that exists naturally in three states of matter, solid, liquid and gaseous states. The solid form is known as ice which may be hard and crystalline as is the case with ice cube or loosely accumulated granular crystals as in snow (Pollack, 2012). The liquid form, generally referred to as water is the most common form available for use by humans and other life forms, while the gaseous form is known as water vapour or steam which forms transparent clouds.

In its purest form, water is tasteless, odourless and nearly colourless with a hint of blue (Braun and Sergei, 1993, Shanna, 2012). It is transparent, thus aquatic animals and plants survive in water because sunlight can penetrate the water and reach them. At standard temperature and pressure, water is a liquid with boiling point of 100°C and melting point of 0°C. The boiling point is largely dependent on the barometric pressure. For example, on the top of Mt. Everest, water boils at 68°C while water deep in the ocean near geothermal vents can reach temperatures of hundreds of degrees and remain liquid (Wikipedia, 2012).

The density of water according to Kotz et al (2005) is 1,000 kg/m³ (1g/cm⁻³) at 40°C while ice has a density of 917 kg/m³. Upon freezing, water density decreases by about 9% and this accounts for ice floating in water. Water is neutral, having a pH of 7. The chemical formula of water is H₂O and each molecule contains two hydrogen and one Oxygen atoms held together by covalent bond. Oxygen attracts more electrons and this gives it a negative charge while hydrogen carries a positive charge. Water molecule therefore has a polar structure and this results in a strong attractive force between the molecules (Wikipedia 2012). These factors account for water's high capillary forces and surface tension (Campbell et al 2006). Vascular plants rely on this property for the conduction of water upwards through the xylem vessels.

Water is a good solvent for many substances. It is regarded as the universal solvent because of its ability to dissolve more substances than any other solvent. Substances soluble in water are known as hydrophilic substances and they include salts, acids, bases, solids like sugars and liquids like ethanol which form a homogenous liquid. Besides these, all gases can dissolve in water to some extent, some very soluble eg ammonia, some slightly soluble eg chlorine and carbon (iv) oxide and others sparingly soluble eg oxygen, hydrogen and nitrogen (Koz et al 2006). However, some substances are insoluble in water. Such substances are said to be hydrophobic and examples include fats, oils, and fat-soluble vitamins (A, D, E and K), (Wikipedia, 2012).

Pure water is an excellent insulator, having a low electrical conductivity. However, as a good solvent, water is never completely free from ions and always has some dissolved solutes in it. If water has even tiny amount of impurities, it can readily conduct electricity. (Wikipedia, 2012).

Furthermore, water can act as an acid or a base. In the presence of a strong acid, water receives a proton and acts as a base, but in the presence of a strong base, water donates a proton and acts as an acid. Added to this, the reaction of water with more electropositive elements may be violently explosive (Koz et al 2005). During such reactions, the elements displace the hydrogen from water to form hydroxides, while hydrogen gas is given off. Being highly flammable, explosion results.

Sources of Drinking Water

Water that is fit for consumption and other uses is called drinking or portable water. Though one of the most common and abundant substances, safe drinking water is becoming increasingly scarce in many places and its availability is one of the major global socio-economic challenges. The problem is more severe in developing countries as a result of poverty, bad governance, corruption and mismanagement.

Access to safe drinking water has improved over the last decades in almost every part of the world. Lomborg (2011) recorded a tremendous increase in the proportion of people with access to safe drinking water in developing countries from 30% in 1970 to 71% in 1990, 79% in 2000 and 84% in 2004 and it is the belief that the trend would continue. Furthermore, the United Nations 2006 report stated that there is enough water for everyone and attributed its inaccessibility to mismanagement, corruption and the inability of the water sector to effect the Paris Declaration on Aid Effectiveness as the Education and Health sectors. However, despite the recorded improvement in the supply of safe drinking water, approximately one billion people still do not have access to safe water (MDG Report, 2008). It is pertinent to note that most countries accepted to reduce the number of people worldwide who do not have access to safe water and sanitation to half by 2015 during the 2003 G8 Evian Summit (G8 Action Plan 2003). Freshwater supply is obtained from the following sources; rain water, spring water, rivers, streams, lakes, wells and boreholes.

Rainwater is the purest form of natural water formed by the condensation of water vapour in the atmosphere. Precipitation from the condensed vapour falls as rainwater. In places where there are no streams and wells, rainwater is collected in underground and surface tanks and used for domestic and other purposes.

Spring water arises from rocks, underground and provides a good source of domestic water as it contains little or no impurities.

Rivers, streams, and lakes are inland fresh water bodies and serve as sources of portable water to many urban, semi-urban and rural communities. Water from these water bodies contains many dissolved mineral salts and organic and inorganic substances which contaminate it. The water should be specifically purified before drinking.

Wells are holes dug below the level of water table with water in them. Well water arises from seepage of ground water into the holes. Wells are important sources of water in many rural and semi-urban areas. The water contains a lot of clay and other mineral salts. Water from deep wells is less polluted than that from surface wells. Well water should be purified before drinking.

Like wells, boreholes are sunk into the ground and they tap water from underground water. Unlike wells, boreholes are very deep and the water is usually pumped out by powerful machines and stored in big tanks from where the water is reticulated through pipes. Borehole water is usually treated with chlorine and iodine before use.

Pollution of Water

To pollute means to make unhealthy, impure or contaminate by discharging harmful substances into the environment in such a quantity as to impair the quality of the environment and constitutes a danger to humans and other life forms. Water at its natural state is pure and good for use and has the natural ability for self purification. The introduction of any physical, chemical, or biological agents in water which changes the water quality, making it unsuitable for desired uses and adversely affecting living organisms is considered as pollution. The chemicals or biological agents causing pollution are known as water pollutants.

Water has suffered tremendous abuse by man and other agents. Almost every activity of man results in the generation of liquid, gaseous or solid wastes and these by products may be potentially hazardous, depending on the source or extent of contamination. Any water body, regardless of its size and location can be polluted. Basically, surface water including rivers, streams, lakes, ponds, rivulets as well as groundwater are prone to pollution. The major water pollutants include refuse, sewage, chemical wastes from industries, agricultural wastes, oil spillage, heat and sediments.

Refuse or waste generally refers to a material or substance which are regarded as useless by the producers or holders and therefore disposed of. In many developing countries, solid wastes comprising biodegradable and non-biodegradable forms as well as sewage of people are often dumped into inland water bodies as well as oceans and seas without treatment (Uwakwe and Iwuala 2009). A large amount of refuse and sewage in water causes an increase in bacterial population, reduction in oxygen level and death of aquatic life (USAID, 2008). In addition, anaerobic break down of wastes lead to the release of such gases as hydrogen sulphide, ammonia and methane which give the water a foul smell and unpleasant taste, making it unfit for any desired use and a source of water-borne diseases like typhoid fever, dysentery and cholera .

In a similar way, many industries produce chemical wastes which include acids, alkalis, dyes, oils, detergents and various metals. Often, these wastes are dumped into water bodies untreated and their effects on aquatic ecosystem are extremely harmful. Many of these chemicals wastes are non-biodegradable and they remain in the water and impact negatively on aquatic life and biodiversity (Uwakwe and Iwuala 2009). Some of the heavy metals bioaccumulate in aquatic organisms and are passed along food chains to the final consumers which are human and results in heavy metal poisoning.

Agricultural productivity is enhanced through the application of fertilizers and various forms of pesticides to control animals and plant pests. These chemicals gain access into water bodies through rain and irrigation. Other agricultural wastes like dead bodies of animals, plant materials and animal excreta are also dumped into nearby rivers, streams and lakes. Added to these, some fishermen use toxic chemicals like garmalin in fishing activities. The nitrates and phosphates in fertilizer and sewage are important plant nutrients and bloom the growth of algae and other aquatic plants. This is called eutrophication. Agricultural wastes leads to death of aquatic animals, bioaccumulation of chemicals and reduction in oxygen level in the water.

Crude oil spills from oil tankers, off-shore oil wells, various sea vessels and bunkering of oil pipe lines by vandals. The oil floats on water surfaces preventing the penetration of oxygen and so suffocating most aquatic life in the affected areas. A large oil spillage has a devastating effects on the ecosystem and poisons the populations of various organisms. Cleaning up large oil spillage is an expensive process and the rehabilitation of the affected area may take several years.

Furthermore, water can also be polluted by the discharge of unutilized heat into water bodies. Many industries and energy generating plants use water in their operations and the heated water is usually discharged into the aquatic environment. This is called thermal pollution. The heated water

is unable to dissolve as much oxygen as cold water and hence the amount of dissolved oxygen is reduced. The aquatic animals that depend on oxygen either die or migrate away.

Sediments are also water pollutants. Sediments from Earth's surface are washed into water by erosion. During rains, certain quantities of sand, silt, clay and other soil materials are washed into water bodies where they settle or float. Sediments have a number of consequences, for example silting of harbours and reservoirs, damage to shell fish, snails, gastropods and increase turbidity of water.

Considering the importance of water to life, polluting water may be the biggest single misuse of water and has a far-reaching effect on humans, other life forms, the environment and the economy of any nation. According to 2007 World Health Organization report. 88% of the 4 billion annual cases of diarrheal diseases are attributed to unsafe water and inadequate sanitation and hygiene and 1.8 million people die from diarrheal disease each year (WHO. 2007). The report further stated that 94% of the cases are preventable through environmental modification, including access to safe water.

Polluted water can be purified to make it safe and clean for consumption and other desired uses. Purification according to Wikipedia (2012) is the process of removing undesirable chemicals, biological contamination, suspended solids and gases from contaminated water. The aim of purifying water is to produce water fit for specific purposes which include domestic, commercial, medical, pharmacological, industrial and agricultural applications.

Purification can take place in small scale or large scale to supply water to houses, commercial and industrial establishments in urban or semi-urban areas. Small scale purification involves such process as boiling, addition of alum, filtration, addition of iodine, chlorination and distillation. On the other hand, in large-scale purification, a pre-treatment screening is carried out to remove large debris like sticks, leaves, rubbish and other large particles which may disrupt treatment processes. The purification processes involves storage of water, coagulation and flocculation, sedimentation, filtration and sterilization with chemicals (Edzwald, 2011, Wikipedia, 2012).

The standards for drinking water are set by government and international agencies such as World Health Organization and UNICEF. The standards typically set the minimum and maximum concentration of contaminants in water to make its use safe and tolerable to living organisms.

Uses of Water

All known forms of life depend on water because water constitutes an essential part of most metabolic process within the body, and also serves as a solvent in which many of the body's solutes dissolve. Water plays vital role in domestic, agricultural, industrial, economic and social development of any nation.

Domestic Uses

Water is used globally in various households for drinking, cooking, washing, general cleaning and bathing. Jeffrey (2000) stated that the human body contains about 55% to 78% water, depending on body size. Studies have shown that it takes about 3,000 litres of water, converted from liquid to vapour to produce enough food to satisfy one person's daily dietary need (Wikipedia 2012).

Agricultural Uses

Water is one of the conditions necessary for germination of seeds, growth and development of

plants and their productivity. The most important use of water in agriculture is for irrigation which promotes large scale agricultural productivity and food security. According to WBCSD Water Facts and Trends (2010), irrigation takes up to 90% of water withdrawn in some developing countries and significant proportions in more economically developed countries. Farmland and animal settlements are established around natural water bodies.

Furthermore, availability of water encourages the establishment of fish ponds, aquaculture, and the rearing of fingerlings. These agricultural potentials which depend on water improve food security, provide substantial income and provide opportunities for employment and community self reliance, all of which contribute substantially to the per-capita income of the country.

Industrial Uses

Water is used in power generation to supply electricity and also employed in many industrial processes and machines. It is used extensively in manufacturing industries, pharmaceutical industries, food processing and chemical industries. Shanna (2012) observed that many of the products we use everyday contain water or were manufactured using it. Water forms the major components of various types of alcoholic and non-alcoholic drinks and other beverages we drink. Food scientists rely on the physical and chemicals properties of water to ensure the success of their products.

Use of Water in Transportation

Basically marine environments offer advantages for the establishment of aqualine and well-defined waterways or maritime routes used by ships and other vessels for maritime trade which involves shipment of heavy cargoes, goods and equipments between various countries. Similarly specific routes are established in large freshwater bodies for smaller ships and passenger vessels. Added to these, ports and wharfs are established in the coastal areas of many countries for berthing of ships and other heavy oceanliners. Also, facilities for import and export of goods, machinery and equipments, and other custom- based transactions are installed.

Consequently, international maritime trade depend on economic uses of marine waterways. Maritime trade and development of viable ports contributes substantially to the per capita income of different countries as they are able to regulate the movement of goods and services, and charge economic tariffs, taxes and other custom charges. Ships and oceanliners also pay demorrhage for the use of coastal areas.

Recreational Uses and Tourism

Water bodies have been used by humans for many recreational purposes which include swimming, boating, water skiing, diving as well as various sporting activities such as ice hockey and ice skating. Many home and commercial centres like Hotels install swimming pool for recreational purposes. Lake sides, beaches, lagoons and water parks are popular places which attract tourists and provide pleasure and beautiful scenario for people to relax and recreate. The use of these recreational and tourist centres attracts revenue to individuals and government, and contributes to the growth of the economy of most countries.

In addition, fountains, aquarium and fish ponds are installed in different homes for decoration, fun, companionship and to earn revenue.

Chemical Uses

Water as the universal solvent is widely used in chemical reactions in the laboratory and within the body of living organisms. Water plays vital role in research, teaching and learning processes such as laboratory demonstration of some experiments. For example transpiration, soil analysis, manufacture of soap and various other laboratory experiments.

Furthermore, water is one of the classes of food required by all living organisms. It provides the medium for all metabolic activities in the body and all the major components in the cells such as proteins, DNA, polysaccharides dissolve in water.

The amount of water in the body therefore affects the osmotic pressure, the pH, salt concentration, the quantity and concentration of urine produced and consequently the internal environment of living cells.

Water as a Habitat

Water provides aquatic environments which comprise the marine and freshwater environments. Marine environments include oceans, seas and saltwater lakes and are characterized by high concentration of salts. On the other hand, freshwater environments comprise rivers, lakes, streams and freshwater lakes which are usually inland and contain salt-free water.

Aquatic environments provide habitats for various kinds of organisms including various type of fishes, snails, reptiles, mammals, amphibians, micro-organisms and various forms of plants. Water bodies also provide breeding places for various animals like mosquitoes and toads. Exploitation of the animals population of aquatic habitats contribute substantially to revenue generation and increase in per capital income of most countries.

Safety Uses

Water is employed in the extinction of fire. Water has a high heat of vaporization and is relatively inert, which makes it a good fire extinguishing fluid (Wikipedia, 2012)? As water evaporates, it carries heat away from the fire and provides a cooling effect. This account for the installation of fire extinguisher in vehicles, laboratories, industries and other establishments especially those vulnerable to fire outbreak.

Similarly in nuclear power industries, water is both a coolant and moderator and this provides a passive safety measure (Wikipedia, 2012).

Tapping and Exploitation of Minerals and Other Natural Resources

This focuses on the effective exploitation of metallic and other mineral resources available in water bodies. Special fees are charged from persons and establishments using the water bodies for commercial fishing and tapping of minerals. Exploitation of sand from rivers and lakes for commercial purposes as well as extended use of water for irrigation and public consumption in urban and semi- urban centres attracts special charges.

Minerals and aquatic life arising from water may provide raw materials for various industry including food processing and canning centres. Effective tapping and exploitation of the various resources from water are sure to boost the revenue earning of different countries and promotes economic development.

Other uses of water includes the application in religion,. Culture, philosophy, literature, politics and civilization (UNESCO, 2006, Wikipedia, 2012).

Management of Aquatic Environment

Environmental management focuses on various type of habitats, their natural resources and how best to exploit and harness these potentials for the benefit of man and other life forms. The essence of environmental management is to help man achieve better sustenance, productivity, and enhanced life span in a healthy, sanitary and supportive environment.

Management of aquatic environments focuses on the exploration and exploitation of the natural resources including plants and animals thriving in different water bodies for improved sustenance. It is generally believed that the bulk of plant and animal lives needed to provide sustenance for humans and animals on land may be found in different water bodies especially oceans and seas which harbour limitless reserve of plants and animals lives.

Aquatic environments generally belong to two broad categories. These are saltwater bodies and freshwater bodies. The saltwater bodies constitute the marine environments consisting mainly of oceans and seas with high salinity values. The freshwater bodies on the other hand are designated freshwater environments and consist mainly of rivers, streams, lakes, ponds and rivulets. The water contents in these environments are sources of portable water.

Management of aquatic environments involves a wide range of measures, strategies and operations, all designed to understand the nature of such environments, exploit the available resources and protect and conserve the natural environments for future beneficial uses. Available measures of management of aquatic environments include especially the following;

- Water quality control and sanitation of the environments.
- Salinity control and regulation of the water chemistry.
- Pollution control and waste management.
- Dredging and physical maintenance of the environment.
- Maintenance of topography and water ways.
- Regulation of populations of aquatic plants and animals.
- Control of water weeds and surface congestion.
- Maritime uses and regulations.
- Water processing, recycling, drainage and reticulation for irrigation and agriculture.
- Underwater and resource exploration.
- Construction of dams or hydroelectricity for improved water supply.
- Fish farming, fishery development and other economic uses of water bodies.
- Ecological regulation and surveillance.

Effective management of aquatic environments is of great socio-economic benefit and also helps to minimize environmental spoilage through the control of pollution, contamination and excessive exploitation. In practice, it is remarkable that virtually all sectors of the economy in each country depend essentially on the environments and its available resources and opportunities. Consequently a progressive and knowledge driven economy may be built on proper understating of aquatic environments as well as terrestrial and aerial environments. Purposeful exploitation of the facilities offered by the environments therefore improves living standard, better longevity and more productive agricultural and industrial activities, and consequently the attainment of sustainable development.

Conclusion

Water is the most essential elements on the surface of the earth. All life forms need it for survival. Humans depend on water for domestic, industrial, agricultural, recreational and various other purposes. Water also provides habitable zones for a large variety of plants and animals, Despite the abundance of water, safe drinking water is scarce in different parts of the globe. This is because inland or freshwater bodies are subject to various anthropogenic activities which lead to the release of different toxic substances which pollute the water bodies. Consumption of polluted water has resulted to the spread of water-borne diseases like diarrhoea, typhoid fever, cholera, and dysentery and these have led to high mortality rate in the world. Effective management of aquatic environments provides sustenance and food security for humans and creates a supportive, healthy and sanitary environment.

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