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Physicochemical Analysis of Surface and Ground Water in Biu Town, Biu Local Government Area of Borno State Nigeria

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ABSTRACT: *The analysis found out that the ground and surface water in Biu metropolis, Biu local government area after been analysed was found to have a standard pH (ranging from 6.8-8.2) which is safe for drinking and domestic use according to the world health organization water quality standard. Electrical conductivity was also measured resulting in an E.C ranging from 0.515 to 0.599.*

KEYWORDS*:* physicochemical analysis, surface, ground water, Biu town, Biu local government area oBorno State, Nigeria

INTRODUCTION

Traditionally, management of water resources has focused on surface water or ground water as if they were separate entities. As development of land and water resources increases, it is apparent that development of either of these resources affects the quantity and quality of the other. Nearly all surface-water features (streams, lakes, reservoirs, wetlands, and estuaries) interact with ground water. These interactions take many forms. In many situations, surface-water bodies gain water and solutes from ground-water systems and in others the surface-water body is a source of ground-water recharge and causes changes in ground-water quality. As a result, withdrawal of water from streams can deplete ground water or conversely, pumpage of ground water can deplete water in streams, lakes, or wetlands. Pollution of surface water can cause degradation of ground-water quality and conversely pollution of ground water can degrade surface water. Thus, effective land and water management requires a clear understanding of the linkages between ground water and surface water as it applies to any given hydrologic setting.

This Circular presents an overview of current understanding of the interaction of ground water and surface water, in terms of both quantity and quality, as applied to a variety of landscapes across the Nation. This Circular is a product of the Ground-Water Resources Program of the U.S. Geological Survey. It serves as a general educational document rather than a report of new scientific findings. "According to oxford dictionary, water is a substance (of molecular formula H_20) found at room temperature and pressure as a clear liquid; it is present naturally as rain and found in rivers, lakes and seas; its solid form is ice and its gaseous form is steam.

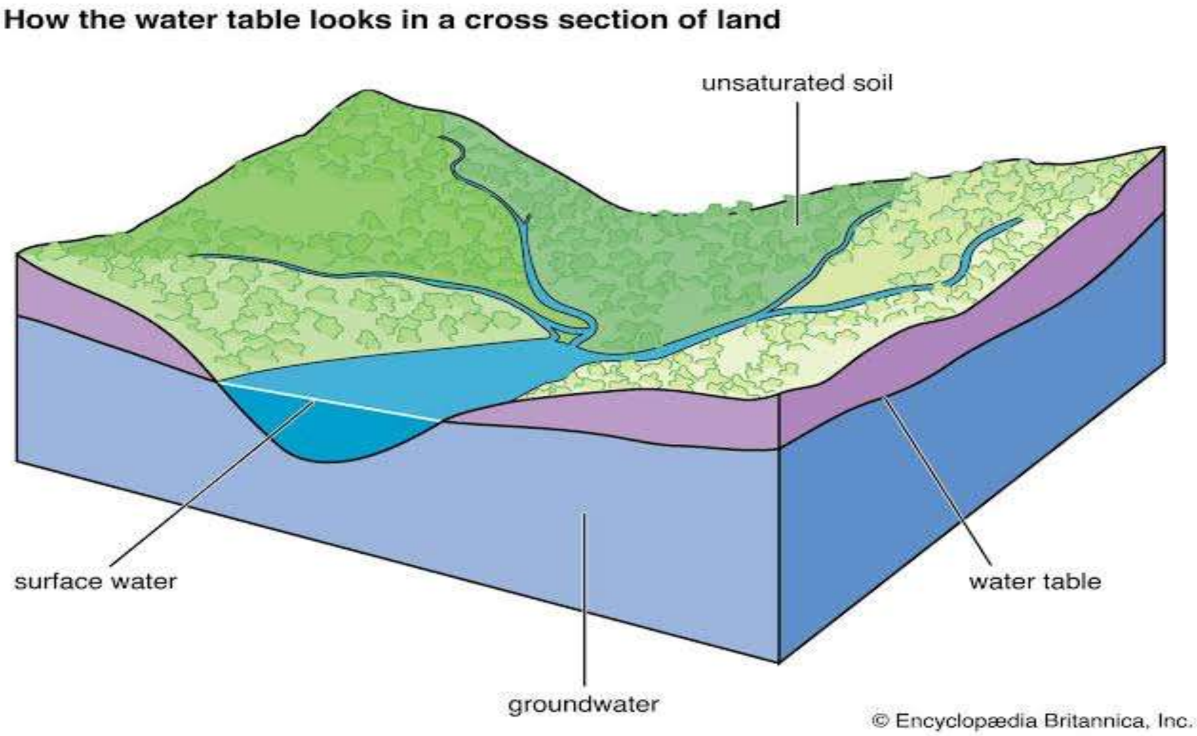

Fig.1 Surface and Ground water

From the above diagram (fig 1.1) we can see that surface water includes the freshwater that is channeled into stream systems, lakes and wetlands on land. Groundwater on the other hand is contained in subterranean aquifers within the rock layers below the water table-the underground boundary that divides the saturated and unsaturated levels of the ground.

Objectives of study

The objectives of this research are to help other Federal, State, and local agencies build a firm scientific foundation for policies governing the management and protection of aquifers and watersheds. Effective policies and management practices must be built on a foundation that recognizes that surface water and ground water are simply two manifestations of a single integrated resource.

Water Cycle and Climate Change

The only naturally renewable source of freshwater globally is precipitation (about110,000 km^3/year). Out of the precipitation occurring over land, a large fraction (70,000 km^3/year) moves back to the atmosphere through evaporation and transpiration from plants [*AbuZeid KM, 2012*]. Infiltration rates vary depending on land use, the character, and the moisture content of the soil, as well as the intensity and duration of precipitation.

In case that the rate of precipitation exceeds the rate of infiltration, overland flow occurs. About 26% of this part of the cycle (18,000 km^3/year) can be used by humans. Worldwide, the total annual runoff, including soil infiltration and groundwater replenishment, is estimated to be 41,000 km^3/year. Geographical remoteness and seasonal issues such as floods limit the total annual accessible runoff to 12,500 km^3/year [*Postel et al., 1996]*. Therefore, it is estimated that about 54% of the accessible runoff and 23% of the total renewable resource (precipitation over land) are currently appropriate for human use in some form.Although globally groundwater is not very significant in volume, it is a critical source of water that can cover the human needs, because it is part of the limited budget of freshwater. From the perspective of long-term sustainability, it is the renewable resource that is most critical. However, it can also be viewed as a nonrenewable resource because the rate that may be withdrawn can be higher than the rate that it is replenished.

Climate change leads to atmosphere warming, which in turn alters the hydrologic cycle. This, depending on the area, results in changes to the amount, timing, form, and intensity of precipitation, the water flow in watersheds, as well as the quality of aquatic and marine environments. Climate change can also change groundwater level and temperature and poses another risk to groundwater and water supply that is not yet well understood, though it needs attention to find solutions for adaptation.

Although several scenarios have been developed to predict the potential impact of climate change, there is still no general consensus on the quantitative effects. However, it is broadly accepted that many semi- or even arid areas will become drier, resulting in less groundwater recharge. In humid zones, recharge is expected to increase due to a higher number of extreme precipitation events. Efforts are being undertaken so as to better understand the climate change mechanisms on a regional and even local scale and hence to be able to determine mitigating measures.

Surface Water

Surface water is accumulated on the ground or in a stream, river, lake, reservoir, or ocean. The total land area that contributes surface runoff to a lake or river is called catchment area. The volume of water depends mostly on the amount of rainfall but also on the size of the watershed, the slope of the ground, the soil type and vegetation, and the land use. Any changes in the water level of a lake are controlled by the difference between the input and output compared to the total volume of the lake.

Surface water is often used for large urban water supply systems, as rivers and lakes can supply a large, regular volume of water. For small community supplies, other forms of water supply, such as wells or spring-fed gravity systems, are generally preferred to surface water. This is because the cost of treatment and delivery of surface water is likely to be high and operation and maintenance less reliable.

Groundwater

Groundwater is a major source of drinking water worldwide and is hosted in aquifers. Hydrological recharge of aquifers hugely varies geographically and strongly depends, among other factors, on climate, geology, soil type, vegetation, and land use [*Scanlon et al., 2002*]. Groundwater is recharged from precipitation, which is complemented by natural infiltration by surface water or by artificial recharge. On a global scale, 20% of the irrigation water and 40% of the water used in industry are derived from groundwater *[Millennium Assessment (2005)]*. Groundwater within an unconsolidated rock moves only a few centimeters a day, i.e., about 10 m/year. Its velocity largely depends on the steepness of the aquifer slopes and the permeability of the rocks. In consolidated rocks the water velocity can be many times higher. A typical example is the karst formations. Groundwater occurs in aquifers under two different conditions, the unconfined and the confined. In an unconfined aquifer, the water only fills the aquifer partly, and its upper surface of the saturated zone may rise and decline. On the other hand, in a confined aquifer, the water completely fills the aquifer that is overlain by a confining bed. The recharge of the saturated zone occurs by percolation of water from the land surface through the unsaturated zone. The advantages of the use of groundwater as a resource for domestic water supply are many. In most inhabited parts of the world, there is a large amount of groundwater, and despite that the abstracted volumes are huge, they are often readily supplemented. Another advantage is that the upper soil layers act as a filter against physical, chemical, and biological deterioration which is effective both in terms of quality and cost. Finally, groundwater use often brings great economic benefits per unit volume compared to surface water because of ready local availability, high drought reliability, and a generally good quality requiring only minimal treatment [*Burke et al., 2000]*.

Chemical Interactions of Ground Water and Surface Water

Two of the fundamental controls on water chemistry in drainage basins are the type of geologic materials that are present and the length of time that water is in contact with those materials. Chemical reactions that affect the biological and geochemical characteristics of a basin include (1) acid-base reactions, (2) precipitation and dissolution of minerals, (3) sorption and ion exchange, (4) oxidation-reduction reactions, (5) biodegradation, and (6) dissolution and exsolution of gases. When water first infiltrates the land surface, microorganisms in the soil have a significant effect on the evolution of water chemistry. Organic matter in soils is degraded by microbes, producing high concentrations of dissolved carbon dioxide (CO_2). This process lowers the pH by increasing the carbonic acid (H_2CO_3) concentration in the soil water. The production of carbonic acid starts a number of mineral-weathering reactions, which result in bicarbonate (HCO_3^-) commonly being the most abundant anion in the water. Where contact times between water and minerals in shallow groundwater flow paths are short, the dissolved-solids concentration in the water generally is low. In such settings, limited chemical changes take place before ground water is discharged to surface. [*Thomas et al., 1998]*.

Acid-base reactions

Acid-base reactions involve the transfer of hydrogen ions (H^+) among solutes dissolved in water, and they affect the effective concentrations of dissolved chemicals through changes in the H^+ concentration in water [*Thomas et al., 1998]*. A brief notation for H^+ concentration (activity) is pH, which represents a negative logarithmic scale of the H^+ concentration. Smaller values of pH represent larger concentrations of H^+, and larger values of pH represent smaller concentrations of H^+. Many metals stay dissolved when pH values are small; increased pH causes these metals to precipitate from solute

Biodegradation

Biodegradation is the decomposition of organic chemicals by living organisms using enzymes. Enzymes are specialized organic compounds made by living organisms that speed up reactions with other organic compounds [*Judsonet al., 1998]*. Microorganisms degrade (transform) organic chemicals as a source of energy and carbon for growth. Microbial processes are important in the fate and transport of many organic compounds. Some compounds, such as petroleum hydrocarbons, can be used directly by micro-organisms as food sources and are rapidly degraded in many situations. Other compounds, such as chlorinated solvents, are not as easily assimilated. The rate of biodegradation of an organic chemical is dependent on its chemical structure, the environmental conditions, and the types of microorganisms that are present [*Thomas et al., 1998]*. Although biodegradation commonly can result in complete degradation of organic chemicals to carbon dioxide, water, and other simple products, it also can lead to intermediate products that are of environmental concern. For example, diethylatrazine, an intermediate degradation product of the pesticide atrazine, commonly is detected in water throughout the corn-growing areas of the United States [*Thomas et al., 1998]*.

Review on the use of environmental tracers to determine the interaction of surface and groundwater

Environmental tracers are naturally occurring dissolved constituents, isotopes, or physical properties of water that are used to track the movement of water through watersheds. Useful environmental tracers include (1) common dissolved constituents, such as major cations and anions; (2) stable isotopes of oxygen ($_{18}O$) and hydrogen molecule (2H) in water molecules; (3) radioactive isotopes such as tritium (3H) and radon (222Rn); and (4) water temperature. When used in simple hydrologic transport calculations, environmental tracers can be used to (1) determine source areas of water and dissolved chemicals in drainage basins, (2) calculate hydrologic and chemical fluxes between ground water and surface water, (3) calculate water ages that indicate the length of time water and dissolved chemicals have been present in the drainage basin (residence times), and (4) determine average rates of chemical reactions that take place during transport. Major cations and anions have been used as tracers in studies of the hydrology of small watersheds to determine the sources of water to stream flow during storms. In addition, stable isotopes of oxygen and hydrogen, which are part of water molecules, are useful for determining the mixing of waters from different source areas because of such factors as (1) differences in the isotopic composition of precipitation among recharge areas, (2) changes in the isotopic composition of shallow subsurface water caused by evaporation, and (3) temporal variability in the isotopic composition of precipitation relative to ground water. Radioactive isotopes are useful indicators of the time that water has spent in the ground-water system. For example, tritium (3H) is a well-known radioactive isotope of hydrogen that had peak concentrations in precipitation in the mid-1960s as a result of above-ground nuclear-bomb testing conducted at that time. Chlorofluorocarbons (CFCs), which are industrial chemicals that are present in ground water less than 50 years old, also can be used to calculate ground-water age in different parts of a drainage basin. 222Radon is a chemically inert, radioactive gas that has a half-life of only 3.83 days. It is produced naturally in ground water as a product of the radioactive decay of 226radium in uranium-bearing rocks and sediment. Several studies have documented that radon can be used to identify locations of significant ground-water input to a stream, such as from springs. Radon also has been used to determine stream water movement to ground water. For example, radon was used in a study in France to determine stream-water loss to ground water as a result of ground-water withdrawals [*Thomas et al., 1998]*.

Effects of Pesticide Application to Agricultural Lands on the Quality of Ground and Surface Water.

Pesticide contamination of ground water and surface water has become a major environmental issue. Recent studies indicate that pesticides applied to cropland can contaminate the underlying ground water and then move along ground-water flow paths to surface water [*Judson et al., 1998]*. In addition, as indicated by the following examples, movement of these pesticides between surface water and ground water can be dynamic in response to factors such as bank storage during periods of high runoff and ground-water withdrawals. A study of the sources of atrazine, a widely used herbicide detected in the Cedar River and its associated alluvial aquifer in Iowa, indicated that ground water was the major source of atrazine in the river during base-flow conditions [*Thomas et al., 1998]*. In addition, during periods of high stream flow, surface water containing high concentrations of atrazine moved into the bank sediments and alluvial aquifer, then slowly discharged back to the river as the river level declined. Applications of pesticides and fertilizers to cropland can result in significant additions of contaminants to water resources. Some pesticides are only slightly soluble in water and may attach (sorb) to soil particles instead of remaining in solution; these compounds are less likely to cause contamination of ground water. Other pesticides, however, are detected in low, but significant, concentrations in both ground water and surface water. Ammonium, a major component of fertilizer and manure, is very soluble in water, and increased concentrations of nitrate that result from nitrification of ammonium commonly are present in both ground water and surface water associated with agricultural lands. In addition to these nonpoint sources of water contamination, point sources of contamination are common in agricultural areas where livestock are concentrated in small areas, such as feedlots. Whether the initial contamination is present in ground water or surface water is somewhat immaterial because the close interaction of the two sometimes results in both being contaminated [*Judson et al., 1998]*.

Effects of Nitrogen Use on the Quality of Ground Water and Surface Water

Nitrate contamination of ground water and surface water in the United States is widespread because nitrate is very mobile in the environment. Nitrate concentrations are increasing in much of the Nation's water, but they are particularly high in ground water in the midcontinent region of the United States. Two principal chemical reactions are important to the fate of nitrogen in water: (1) fertilizer ammonium can be nitrified to form nitrate, which is very mobile as a dissolved constituent in shallow ground water, and (2) nitrate can be denitrified to produce nitrogen gas in the presence of chemically reducing conditions if a source of dissolved organic carbon is available. High concentrations of nitrate can contribute to excessive growth of aquatic plants, depletion of oxygen, Fishkill's, and general degradation of aquatic habitats. For example, a study of Waquoit Bay in Massachusetts linked the decline in eelgrass beds since 1950 to a progressive increase in nitrate input due to expansion of domestic septic-field developments in the drainage basin. Loss of eelgrass is a concern because this aquatic plant stabilizes sediment and provides ideal habitat for juvenile fish and other fauna in coastal bays and estuaries. Larger nitrate concentrations supported algal growth that caused turbidity and shading, which contributed to the decline of eelgrass [*Judson et al., 1998]*.

World Health Organization (W.H.O) water quality standard

Drinking water quality standards describes the quality parameters set for drinking water. Despite the truth that every human on this planet needs drinking water to survive and that water may contain many harmful constituents, there are no universally recognized and accepted international standards for drinking water. The development of global guidelines ensuring the appropriate use of evidence represents one of the core functions of WHO. A WHO guideline is defined broadly as any information product developed by WHO that contains recommendations for clinical practice or public health policy. According to world Health organization (W.H.O) 2011 standard, calcium permissible range in drinking water is 75 mg/l. In the study areas, results show that the concentration of calcium ranges from 2.16 to 7.31 mg/l in Wondo Genet campus with an average value of 5.08 mg/l.

Generally, the amount of dissolved solids in water determines the electrical conductivity. Electrical conductivity (EC) actually measures the ionic process of a solution that enables it to transmit current. According to WHO standards, EC value should not have exceeded 400 µs/cm. pH isn't a quality that falls under EPA regulation because it's considered an aesthetic quality of water.

METHODOLOGY

Research Area

The study was carried out in the city of Biu. Nigeria's southern Borno State is home to the town and Local Government Area (LGA) of Biu. The town, which was formerly the capital of the Biu kingdom and is currently the capital of the Biu Emirate, serves as the LGA's administrative hub. At an average elevation of 626 meters, Biu is located on the Biu Plateau. It is a semi-arid area. Biu was once known as Viu, which means lofty in the Babur and Bura languages. Mari Watila Tampta's reign, which began approximately 1670, saw the establishment of the Biu kingdom. Fulani invaders from the Gombe Emirate to the west were routed by King Mari Watirwa (r. 1793–1838), whose capital was close to Biu at Kogu. Mari Biya, a woman, became the first Babur monarch to rule from Biu, did so in 1878. The town is home to the Great Nigerian Army University, or Biu. In 1918, the Biu division was established under British administration. In 1920, Mai Ari Dogo was recognized as the first emir of Biu. After the addition of the Shani and Askira districts to the emirate in 1957, the region began to be known as the Biu federation. In 1959, Maidalla Mustafa dan Muhammad (born in 1915) adopted the name Mai Biu, popularly known as Kuthli. Pabir (also known as the "Babur" or Bura"), Tera, Bura, Marghi, Mina, and Fulani people make up the majority of the region's population. The Chadic language family includes the Biu-Mandara languages Babur, Bura, Tera, Marghi, and Mina. With the exception of a small section in the northeast, the Kimba area, which is located in the drier Sudan savannah zone, the LGA is largely situated in the northern Guinea savannah (NGA) arcecological zone. The economy is built on producing sorghum, millet, maize, cowpeas, and cotton as well as herding cattle, goats, sheep, horses, and donkeys. Most farming is done on small farms using conventional techniques. Iron ore, gravel, magnesite, uranium, feldspar, topaz, mica, granite, aquamarine, nephelite, and salt are all exploited in Biu's tiny mining sector. The Gombe-Biu-Mubi road was in disrepair as of 2010. The region was designated to receive crucial infrastructure financing from many international organizations in early 2022 to enhance transportation connectivity. There are a lot of people in the Biu Local Government. The Balbaya, Buratai, Charenji, Chemi Moda, Dula, Dibirow, Filin Jirgi, Galdimare, Garubula, Garundana, Gunda, Gur, Kabura, Kagul, Kimba, Kirkidum, Kogu, Kunar, Kumari, Kugur, Kwaya Kusar, Maina Hari, Mandafuma, Mandagirau, Mangada, Mbulamel, Mirnga.

MATERIALS AND METHODS

Four samples in total were taken from four separate locations, all of which were visited during the rainy season, i.e. (August 2022). The samples were gathered in water-filled plastic bottles and transported safely to the laboratory. All samples had the appropriate labels applied so they could be identified. Temperature, pH, and electrical conductivity were among the variables assessed. Standard techniques were used to analyze the grab sampling.

The samples were examined for the physiochemical factors listed below: electrical conductivity (s/m), pH, and water temperature (°C).

Determination of physico-chemical parameters of drinking water

a. Determination of pH

The pH of obtained samples were measured with a pH/temperature meter at Nigerian army university chemistry laboratory faculty of natural and applied science. The pH meter was first calibrated with buffer solution (pH 4.00) before taking the measurement. AfterthecalibrationofthepHmeter,theprobeofthepHmeterwassubmergedinabeakerofwatersampleandheldforacoupleofminutestoachieveastabilizedreading.Aftertakingreadingforthefirstsample,theprobewasrinsedwithdistilledwatertoavoidcrosscontaminationamongdifferentsamples.

b. Determination of Electrical conductivity (EC)

Electrical conductivity was measured using conductivity meterat Nigerian army university biu chemistry laboratory faculty of natural and applied science. Before measuring the probeswererinsedwithdistilledwaterandpurity of distill water was checked. Thentheprobewasimmersedinbeakercontainingwatersampleandmovedupanddowntapedonthebeakertobefreethe electrodes from any bubbles.Then data was recorded for each sample.

RESULTS

Sample	**Location / points of collection**	**pH**	**Electrical conductivity (M/s)**
A	A small water body at Tabra-Tsahuyam close to Haske water factory.	**8.2**	**0.579**
B	A flowing river located at Bubalwada	**6.8**	**0.515**
C	Al-mohap filling station opposite Nigerian Army University Biu.	**7.2**	**0.599**
D	Faculty of Natural and Applied Science Nigerian Army University Biu	**7.8**	**0.515**

Table 4.1 pH and Electrical conductivity of water samples
<u>Note</u> : All measurement were done at constant temperature (25°C)

DISCUSSION AND CONCLUSION

Discussion

Groundwater plays an important role for urban water supplies. Nowadays that thereis recognition of the vertical dimension of hydrologic connectivity [*pringle c. 2003*] and consent that many surface water ecosystems depend on groundwater at different levels, conservation and management of this linked resource are even more important [*Boulton AJ 2005)*].For the efficient and sustainable exploitation, management, and remediation of ground water resources, it is important to know the water and contaminant flow patterns and the way they interact with the geological formations. Assessment and monitoring of water resources and their quality are generally a routine in developed countries. However, this is not always the case in developing or in remote areas where vulnerable communities are hugely affected by poor water quality [*UNEP 2010*]. Areas that suffer from limited availability or accessibility of water resources may also be at greater water risk [*WHO 2011*] especially if limited water resources are undermined by natural and anthropogenic contamination, climate change, or other factors as poverty, remoteness, insufficient water management, and lack of treatment [*Garret V et al., 2008*].

Certain measures for groundwater protection such as reduction in water consumption, enhancement of artificial recharge use, pollution control, and holistic management of groundwater resources are taken.

Conclusion

The ground and surface water in Biu metropolis, Biu local government area after been analysed was found to have a standard pH (ranging from 6.8-8.2) which is safe for drinking and domestic use according to the world health organization water quality standard. Electrical conductivity was also measured resulting in an E.C ranging from 0.515 to 0.599m/s.

References

Pringle C (2003) What is hydrologic connectivity and why is it ecologically important? Hydrol Process 17(13):2685–2689

Boulton AJ (2005) Editorial: chances and challenges in the conservation of ground waters andtheir dependent ecosystems. Aquat Conserv 15:319–323

UNEP (2010) Africa Water Atlas. Division of Early Warning and Assessment (DEWA), United Nations Environment Programme (UNEP), Nairobi, Kenya

World Health Organization (2011) Non communicable diseases country profiles. Geneve.http://apps.who.int/iris/bitstream/10665/44704/1/9789241502283_eng.pdf

Cai WJ, Wang Y, Krest J, Moore WS (2003) The geochemistry of dissolved inorganic carbon in a surficial groundwater aquifer in North Inlet, South Carolina, and the carbon fluxes to thecoastal ocean. Geochim Cosmochim Acta 67:631–639

Garrett V, Ogutu P, Mabonga P, Ombeki S, Mwaki A, Aluoch G, Phelan M, Quick RE (2008)Diarrhoea prevention in a high-risk rural Kenyan population through point-of-use chlorination,safe water storage, sanitation, and rainwater harvesting. Epidemiol Infect 136(11):1463–1471

Hanjra MA, Ferede T, Gutta DG (2009) Reducing poverty in sub-Saharan Africa through investments in water and other priorities. Agr Water Manage 96(7):1062–1070

Ferrier RC, Jenkins A (2010) The catchment management concept. Handbook of catchment management. Wiley-Blackwell

Konstantina Katsanou IHE Delft Institute for Water (2017).

Hrissi K Karapanagioti University of Patras (2017).

Scanlon B, Healy R, Cook P (2002) Choosing appropriate techniques for quantifying groundwater recharge. Hydrgeol J 10:18–39

Millennium Assessment (2005) Millennium ecosystem assessment. Ecosystems and human well-being: wetlands and water synthesis. World Resources Institute, Washington, DC

Burke JJ, Moench M (2000) Groundwater and society: resources, tensions and opportunities. United Nations, New York

U.S. Environmental Protection Agency (1993) A review of methods for assessing aquifer sensitivity and ground water vulnerability to pesticide contamination. U.S. EPA/813/R-93/002, EPA, Washington, DC

Changping Y, Tingfang S, Liangyu J, Tingzuo W, Shaodu L (1993) Exploration and evaluation of groundwater well field. Geological Publishing House, Beijing

AbuZeid KM (2012) Mediterranean water outlook: perspective on policies and water management in Arab countries. In: Choukr-Allah R, Ragab R, Rodriguez-Clemente R (eds) Integrated water resources management in the Mediterranean region: dialogue towards new strategy. Springer Science & Business Media, Dordrecht

Postel SL, Daily GC, Ehrlich PR (1996) Human appropriation of renewable fresh water. Science 271(5250):785–788