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Assessment of the use of surface water and its environmental health effects in Ekpoma, Nigeria

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Abstract

This study which benefits from field data and hydro-climatic literature examines the use of surface water and its environmental health effects in Ekpoma, Nigeria. It identifies rainfall, borehole, public tap and rivers as the main surface water resources which are used by the residents for domestic, agricultural, institutional, industrial, and research activities in Ekpoma. It observes that owing to poor road surfaces, failed power sources, obsolete water purification facilities, little maintenance funds, absence of specialists, increased fuel price, poor surveillance of facilities, inadequate security and existence of pervious catchment basins, the residents do not have adequate access to clean and purified surface water resources for daily uses. These limitations led to occurrence of water-induced diseases as cholera, diarrhea, dysentery, gastroenteritis, malaria, ringworm, trachoma and typhoid fever in Ekpoma. Based on these findings, the study suggests among others that adequately clean and purified surface water resources managed by specialists, reinforced with modern facilities and sufficiently funded by the state government should be supplied to the residents to eliminate these rampant diseases in the settlement.

Keywords: Surface Water; Use; Environment; Health Effects; Ekpoma-Nigeria

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1. Introduction

Water is one of the most significant environmental resources in the Planet Earth. It co-exists with the landforms, atmospheric winds, fauna, flora, micro-organisms, agricultural produce and human-made social, economic and political infrastructures. Water occupies 71% of the Earth's surface. Conventionally, it appears as a transparent fluid which is found abundantly in the world's rivulets, brooks, bays, streams, lagoons, lakes, rains, rivers, seas, glaciers, oceans, subterranean interstices and retentive aquifers. Characteristically, natural water exists either in liquid, solid, or gaseous form. It is tasteless, odourless and almost colourless in nature. At a standard temperature of 25^0C and conventional pressure, natural water occurs on the earth's environment in liquid form. Biologically, water constitutes the major fluid of all living things. In reality, the human's brain and heart contain 73% of water, the lungs 83%, the skin 64%, the bones 31%, and the muscles and kidneys 79%. Each day, a healthy person consumes some amount of water to survive, and this varies according to age, gender, climate, nutrition, daily exercise and the specific place the person lives and works. As Aiboni (2016) observes, an adult male who lives in the humid tropics of the world drinks 3.0 litres of water per day while the adult female consumes 2.2 litres of water daily.

The presence of clean water in the human body serves some vital functions: it aids the movement of masticated food substances from the mouth into the stomach and facilitates the final processes of digestion, assimilation and absorption; it forms the biological medium for the formation and circulation of human blood; it assists the both human sexes in the mutual exchange of essential physiological fluids which results to procreation of new offspring; it spurs the regular discharge of metabolic wastes from the human body in addition to promoting respiration, irritability and sustaining body weight for effective human movement on the earth's surface. This background suggests that water is the most indispensable natural fluid which is required for human sustenance, existence, and survival on the environment.

Water is most useful to man's existence and the development of the world. It is required for drinking, cooking of foods, washing of clothing, cleaning of houses, agricultural and industrial activities, hydro-electric power generation, movement of cargoes and people, fishing, tourism and sports, and for the demarcation of national and international boundaries among states and countries of the world. River, sea and ocean waters form important habitats for a variety of useful animals. Also, these surface water resources provide abundant crude oil and gas for refinement in petrochemical industries. Consequently, domestic and foreign currencies are realized from the sale of these refined petroleum products. In addition, the water bodies release abundant moisture as warm convective current into the troposphere which condenses as rainfall. Rainfall mitigates harsh environmental conditions and recharges most streams and rivers which are susceptible to seasonal evaporation spurred by excess radiation and dry winds. It is not surprising to observe that early civilizations such as those of the Nile in Egypt, Indus in India, Hwang Ho in China and the Euphrates Tigris in Ancient Mesopotamia flourished around the river valleys owing to abundant drinking water, adequate alluvial sands for farming and construction works, availability of nutritious river foods, convenient transportation and suitable climate for healthy human existence (Ayoade, 1988; Okhakhu, 2014).

Environmental water circulates continually through the water cycle which is driven by the sun's energy, microclimatic forces, the pressure gradient force, and the warm atmospheric winds. This circulation starts in

the larger water bodies such as the rivers, seas and oceans and extends to the thickly vegetated surfaces in the processes of evaporation and transpiration. There is natural pressure reduction in the immediate troposphere which results to saturation and condensation. Rain eventually falls leading to environmental run-off. The run-off percolates the crust's layers and runs towards the rivers, seas and oceans. The process starts again and proceeds endlessly. Evaporation and transpiration contribute significantly to rainfall which is experienced over land. Although it is impossible to increase the earth's supply of water for man's use and allied activities, but we can manage the water available on the environment more effectively through water conservation. The term *water conservation* is used in this study to refer to meticulous utilization and protection of surface water resources from impurities with regard to quantities and qualities. The water conservation process extends to include the careful treatment of surface water resources through the applications of filtration, sedimentation, coagulation, chlorination, coppering and fluoridation techniques the objective of which is to eliminate water-borne diseases which are capable of causing undetected ailments in the communities. It ends when the clean, safe, and purified water gets to the final place for man's use and for other relevant activities in the country.

Water conservation constitutes a vital component of sustainable water use in the world. By sustainable water use, it implies the use of water by the people that allows the current society to develop and flourish into a vibrant future without degrading the essential components of the hydrological cycle and the corresponding ecological system which depends on it. In this study, surface water resources specifically refer to the waters available on the earth's surface which are derived from the ponds, rivulets, streams, rivers, boreholes, hand-dug wells, public faucets and rain water stored in surface tanks.

The supply of clean surface water in adequate quantity for drinking, personal hygiene, domestic chores, industrial use and surface sanitation is essential to public health and the overall well-being of the immediate community. In Nigeria, most of the people derive their daily water for drinking and allied domestic uses from the streams, rivers, rainwater stored in tanks, boreholes and hand-dug wells. These surface water resources are rarely free from exposure to different environmental pollutants. In the Niger-Delta Region, crude oil wastes, gas flaring and industrial chemicals are carelessly deposited in the ravines, streams and rivers by local and foreign established petroleum and chemical industries. In the Lagos-Ibadan-Abeokuta Industrial Region, different types of industrial effluent, human excreta, decayed remains of dead cattle, goats, sheep and poultry, condemned engine oil and worn-out vehicular parts are discharged into the water bodies. Also, hazardous chemicals used for fishing by primitive fishermen have escaped undetected into the immediate Lagos lagoon (Okhakhu, 2016). This similar scenario of surface water pollution through reckless anthropogenic activities is currently observed in the Northern, Middle, Mid-West and Eastern Parts of Nigeria.

In Nigeria, there is poor access to clean and safe surface water for man's use. Over 66 million people are affected in this regard. Poor environmental sanitation, uncivilized habits, high illiteracy, little capital, brain drift, and inadequate sanitary facilities have caused this situation. According to Aboni (2016), approximately 109 million people lack access to proper sanitation and adequate sanitary facilities in Nigeria. In most rural areas and cities in Nigeria, the residents have formed the habit of dumping hazardous wastes into the surface water bodies. These waste deposits have bred a colony of water-borne diseases having undergone major

changes in the surface water bodies. As observed by scientists, the outbreaks of dangerous water-borne diseases such as cholera, diarrhea and typhoid fever have caused tremendous hardships on different countries, and consequently decimated tens of thousands of people across the world (Ayoade, 2004; Aboni, 2016). However, these past surface water-induced challenges must not be sustained in the face of current global scientific advances and technological exploits. It is in conformity with these scientific guidelines that this current study examines the sources and uses of surface water resources in Ekpoma, Nigeria. It examines the means of extraction and storage of surface waters, and discusses the limitations of surface water provision in the settlement. Finally, the study examines the chemical and microbiological qualities of surface water resources in Ekpoma, Nigeria.

2. Materials and methods

This study used field data derived from Ekpoma and hydro-climatic literature. Reconnaissance and field surveys were carried out in the settlement. The reconnaissance survey took place within November 2016 and February 2017. This period was the heart of the dry season in the study area when the water required for domestic, agricultural, institutional, commercial and industrial uses was scarce and difficult to exploit by the urban residents. The sources of surface water resources identified during the observations were Rivers Ibiekuma and Ogedekpe, boreholes, public faucet and rainfall. The actual field surveys which spread from March-October 2017 served as the second vital phase which enabled data collection on all aspects of the study to be realized. The data on the sources, uses, extraction and storage of surface water resources were obtained through direct discussions with the residents, drivers of water tankers, physical observations and administration of structured questionnaires to the respondents. Water samples from rainwater stored in surface tanks and the two rivers were obtained from the surface, middle and bottom layers with eight standard water beakers for both chemical and bacteriological tests at the water laboratories in Okhoro District, Benin City, Nigeria. The aim was to assess the surface water quality being utilized in Ekpoma. Analyses and results of the 464 retrieved questionnaires out of the total 500 copies administered to the respondents are shown in Tables 1, 2, 3, 4, and 5. Finally, the details of the water tests, analyses and assessments in comparison with the World Health Organization's (1984) standards are shown in Tables 6, 7, and 8.Table 9 shows the water-related diseases which are prevalent in Ekpoma based on assessed hospital records. A post field survey assessment of the climate of surface water resources in the settlement was carried out, and this led to inevitable procrastination in the final report writing.

3. The study area

The study area is Ekpoma in Edo State, Nigeria. Ekpoma is a prominent, humid tropical urban settlement which is found in the south-western part of Nigeria. The town is located within Latitudes $6^{0}44^{1}$N and $6^{0}45^{1}$N and Longitudes $6^{0}06^{1}$E and $6^{0}08^{1}$E. Currently, Ekpoma serves as the administrative headquarters of Esan West Local Government Area in Edo State. According to Aiboni (2016), it is made up of several quarters which are Eguare, Emaudo, Emuhi, Idumebo, Ihumudumu, Ileh, Iruekpen, Uhiele, Ujemen, Ujoelen, Ukhun, Uke and Ukpenu. Egoro, Irrua, Urohi and Ehor bound Ekpoma in the north, east, south and west respectively.

Physically, basement complex and sedimentary rocks dominate the relief scenery of Nigeria. Specifically, the basement complex rocks are found in the northern, western and some parts of the north-eastern regions while the sedimentary rocks constitute the coastal areas of south-eastern and some parts of western Nigeria, the Niger and Benue Troughs, and the Sokoto, Gongola and Chad Basins (Odemerho, 1988; Jeje, 1993). This scenario suggests that the relief of the study area contains sedimentary rocks of the Miocene Pleistocene Age at the surface level which are relatively stabilized underneath by the basement complex rocks. These sedimentary rocks, as observed at Ukhun, Uhiele, Ujoelen and Ujemen, do not contain sufficient subterranean and surface water resources owing to displaced formation of landforms and absence of retentive viable catchment basins.

Except Iruekpen in the south which is sited on a deeply dissected, intertwined slope-valley surface, Ekpoma is sited on the summit of a partly flat-undulating Esan Plateau which, assessed underneath, is largely deficient in water retentive aquifers. More so, the surface of the study area slopes towards the eastern part, and there is absence of a range of highlands which could serve as viable catchment basins for surface rivers like those observable in Akoko-Edo, Etsako East and West Local Government Areas of Edo State. As Aiboni (2016) observes, the catchment basin (CB) is a very important element in ground and surface water studies with regard to aspects of water reception, accumulation, retention, recharge, flow, and supply to the people for different purposes. This suggests that a suitable CB yields abundant water for a settlement to use while an undulating type facilitates instant surface run-off to other water retentive sites. Based on its undulating relief towards the River Niger Basin, both surface and subterranean water retention in abundant quantity is hardly a reality in Ekpoma. This is the main reason the residents place much attention on surface water exploration, extraction, retention, and utilization within the seasons, oftentimes.

Two small rivers drain the study area. These are Rivers Ogedekpe and Ibiekuma. River Ogedekpe is found in the northern part of Ukhun settlement while River Ibiekuma drains the western part of Ujemen. The second river takes its headwaters from the Ambrose Alli University Campus where it is dammed and exploited as a major source of water supply in Ekpoma specifically during the wet and dry seasons. Ekpoma is located within the humid tropics in the Mid-West of Nigeria. Owing to this factor, the town experiences the humid tropical climate (Iloeje, 1982) which is characterized by definite wet and dry seasons determined fundamentally by the seasonal shifts in the pressure belts associated with the apparent movement of the overhead sun (Okhakhu, 2016). The wet season spans a distinct period of nine months with torrential rains characterized by intermittent lightning, thunderstorms, grey clouds and run-off induced surface denudation. It starts in March and subsides in November while the dry season extends through late November to mid-February where it retreats northwards towards the Sahara Desert. It is a truly chilly period of dust storms intertwined with smog, hot-dry winds from the Sahara Desert, and noisy breeze-induced season. The dry season in the settlement is relatively famous for occurrence of dry dusts, rainless days, and prevalence of human ailments as cough, catarrh, itching skins, coarse utterances, excessive perspiration, dehydration and debilitating fever.

The mean annual rainfall amounts recorded in Ekpoma in 2007 and 2011 are 1,850mm and 1,992mm (Meteorological Station, 2011). The town observes a double rainfall cycle in March-July and September-October annually. Highest rainfall values between 345mm and 351mm are recorded in July and

October. These rainfall values are induced by increased radiation effects, extensive surface evaporation and vegetal transpiration, rapid saturation and widespread condensation in the lower troposphere. Its mean annual temperature is 27^0C while its observed humidity fluctuates from 62%-77%. The humidity value stabilizes in the morning, fluctuates in the afternoon, and gradually enhances at sunset.

Its environment supports the tropical rainforest owing to its climate of heavy convective rains, warm moisture, refreshing maritime winds, mild temperature, suitable sunshine, and adequately formed fertile soils rich in vast humus with active colony of micro-organisms. Tall and giant trees with straight and tiny green leaves named Obeche, Walnut, and the Black and White Afara are found in Ekpoma. Over the years, shifting cultivation, road constructions and erection of different buildings have spurred extensive destruction of this natural vegetal cover. This led to emergence of derived savanna in some parts of the town and impaired transpiration in the lower troposphere with heavy toll on the convective precipitation.

The original inhabitants of Ekpoma are called the Esan people. They migrated from the Ancient Benin Kingdom about the 14th century. A large section of Ibo, Hausa, Fulani, Igbira, Yoruba and Afenmai nationalities have migrated to join the original Esan people owing to abundant socio-economic benefits derivable from the Ambrose Alli University with its attractive huge market. At the completion of the 1991 national census, the town's population stood at 55,089. In 2014, the projected population of the town rose to 92,905 (Aiboni, 2016). Field studies reveal that the residents are involved in farming and sale of farm produce like pineapples, rice, pears, plantain and banana to the urban areas, construction works, education and bank services. Other lucrative activities include small-scale industrial works, transport and communication services. This suggests that some of the human activities and the residents require adequately safe and secure surface water resources for daily operations and survival.

4. Results and discussion

4.1. Sources, means of extraction, storage, and uses of surface water resources in Ekpoma

Tables 1 and 2 depict the main sources of surface water resources in Ekpoma. Rainfall, rivers, boreholes and public tap are identified. Ten quarters are selected randomly out of the total sixteen quarters identified in Ekpoma. This selection produces a spatial coverage of 92.08%. Physical observations, direct assessment and field responses show that rainfall with 54.09% is the most abundant, widespread and reliable source of surface water in the settlement. Borehole water with 18.10% is second, public faucet bearing 16.37% is third and river water with 11.42% is the least in the categories identified. Eguare, Ujoelen and Uhiele depend largely on rainfall and borehole water for domestic and allied activities. Although river and public faucet waters are used at Ujemen, Idumebo and Ihumudumu owing to proximity to these surface water resources, much public focus is placed on rainfall and borehole waters for different uses because of fair spatial distribution, duration, accessibility and affordability within the seasons. These facts are clearly depicted in Tables 1, 2 and 4.

Table 1. Sources of Surface Water Resources in Ekpoma

S/N	Quarters	Rainfall	Rivers	Boreholes	Public Tap	Total
1	Eguare	27	4	14	2	47
2	Emaudo	26	6	12	1	45
3	Emuhi	33	10	1	0	44
4	Idumebo	24	7	2	15	48
5	Ihumudumu	23	3	6	13	45
6	Iruekpen	24	4	7	11	46
7	Uhiele	23	2	15	7	47
8	Ujemen	20	3	3	22	48
9	Ujoelen	25	0	16	5	46
10	Ukhun	26	14	8	0	48
11	Grand Total	251	53	84	76	464

Source: Field Surveys, 2017

Table 2. Surface Water Sources in Ekpoma

S/N	Surface Water Sources	Frequencies	%
1	Rainfall	251	54.09
2	Rivers	53	11.42
3	Boreholes	84	18.10
4	Public Tap/Faucet	76	16.37
5	Total	464	100

Source: Field Surveys, 2017

Table 3. Means of Water Extraction and Storage in Ekpoma

S/N	Means of Water Exploitation and Storage	Freq	%
1	Bowls	56	12.06
2	Plates	40	8.62
3	Drums	64	13.79
4	Dug Tanks	150	32.32
5	Engine Trucks	54	11.63
6	Pipelines	10	2.15
7	Plastic tanks	90	19.39

Source: Field Surveys, 2017

Field surveys show that rainfall and borehole water are the most important sources of surface water supply in Ekpoma. In reality, the borehole water is conveyed to Ekpoma by water tankers from Irrua which is a sister town in Esan Central Local Government Area in Edo State. As discussed with the residents, borehole water is subterranean water which is electrically extracted into the surface with activated mechanical equipment. The residents insisted that borehole water was the singular source of surface water supply to them during the dry season. This robust submission was sustained. Table 3 shows the means of surface water extraction and storage in the settlement. Of these observed means, dug tanks (32.32%), plastic tanks (19.39%), drums (13.79%) and bowls (12.06%) are the most affordable by the residents. The uses of surface waters are shown in Table 4. Domestic, institutional, agricultural, industrial, and research purposes

are identified. The surface water which is used at schools, offices, churches, mosques, hotels, and restaurants is regarded as 'institutional use' in the study.

Table 4. The Uses of Surface Water Resources in Ekpoma

S/N	Functional Division	Major Water Uses
1	Domestic uses	Drinking, cooking, laundry, bathing, sanitation, gardening, etc
2	Institutional uses	Drinking, sanitation, washing, watering of lawns, religious services.
3	Agricultural uses	Spraying of gardens, feeding animals, making organic manures, fish and snail ponds, palm oil extraction, cleaning farm tools.
4	Industrial uses	Drinking, sanitation, machinery cooling, brewing drinks, snacks making, weather conditioning, sachet and bottled water manufacture, etc.
5	Research	School experiments, field studies, scientific hydrological illustrations.

Source: Field Surveys, 2017

Table 5. Challenges of Surface Water Provision in Ekpoma

S/N	Challenges of Water Provision	Freq	%
1	Inadequate Rainfall	20	4.31
2	Erratic power supply	46	9.91
3	Poor surfaces of roads	51	10.99
4	Inadequate water trucks and tankers	34	7.32
5	Obsolete exploitation equipment	38	8.18
6	Increase in fuel rice	42	9.05
7	Managerial inefficiency	38	8.18
8	Inadequate funds	49	10.56
9	Global economic recession	35	7.54
10	Inadequate storage facilities	11	2.37
11	Unhygienic water treatment	46	9.91
12	Absence of hydrologists	36	7.75
13	Atmospheric pollution	08	1.72
14	Pervious catchment basins	10	2.15
15	Total	464	100

Source: Field Surveys, 2017

4.2. The challenges of surface water provision in Ekpoma

The concepts of adequate water provision and utilization are used in the study to buttress its relevance. Water, based on the surface sources observed in the field, must be available, cheap and accessible to all the urban users at any given place and time. If foreign particles are detected in the surface waters, there is need to purify the waters. This creates room for standard surface water quality tests in the laboratories, analyses, and purification. On completion of these vital requirements, the supply of adequate quality water to the residents becomes a social responsibility which must be carried out either solely by the government or largely through private-public sponsorship. The residents through routine payment should fetch, accept, store and utilize this purified water of standard quality. This realizes the both concepts of adequate water provision and utilization. However, when the water purification standards are avoided by the water supply

authorities, the challenges of water provision become reality. Table 5 presents these observed water limitations in the study area. Poor surfaces of the roads which lead to break down of water tankers (10.99%), inadequate public funds required for the maintenance of roads, underground water pipelines and surface faucets (10.56%), erratic power supply to extract borehole water from the underground aquifers (9.91%), unhygienic water purification (9.91%) owing to absence of water treatment and assessment laboratories, and increased fuel price (9.05%) are the fundamental limitations of water supply observed in the field.

There are other limitations of poor management at the water factories (8.18%), absence of rains from November to February (4.31%), preponderance of obsolete water extraction facilities (8.18%), inadequate storage facilities (2.37%), absence of hydrologists (7.75%), and existence of pervious catchment basins (2.15%) which is a long time physical result of the displaced geological formation of the settlement. The recent hike in fuel price has raised the overall water cost in the settlement. Field studies reveal that a big plastic tank sells between ₦3,000.00 and ₦3,500.00, a small plastic tank sells between ₦1,000.00 and ₦1,500.00 while the little 20 litre-jerry can is purchased at ₦20.00 during the wet season and ₦25.00 at the start of the dry season.

4.3. Chemical and microbiological qualities of surface waters in Ekpoma

The aim of water quality tests and assessment is to ensure its safety for human consumption with a view to preventing ailments. In circumstances where extraneous particles are detected in surface water resources, suitable treatment measures are devised for urgent implementation at the sites of such surface waters. These require suitable water treatment facilities, adequate chemicals, sufficient funds, specialized management and functional community-government partnership to succeed.

Table 6. Chemical Parameters of Water Samples A, B, C and WHO's Drinking Water Standards

S/N	Parameter	Unit	Sample A	Sample B	Sample C	WHO's Limit
1	Aluminium	Mg Al/L	-	-	-	0.2
2	Arsenic	Mg AS/L	0.002	0	0.01	0.05
3	Barium	Mg Ba/L	-	-	-	0.05
4	Berglium	Ug Be/L	-	-	-	02
5	Cadmium	Ug cd/L	0.003	0.008	-	5.0
6	Calcium	Mg ca/L	1.50	1.20	1.50	200.0
7	Chronium	Mg /Cr/L	0	0.001	0.005	0.05
8	Copper	Mg cu/L	0.01	0.04	0.002	I.0
9	Iron Total	Mg Fe/L	3.99	3.50	0.05	0.3
10	Lead	Mg ph/L	0.001	0	0.02	0.01
11	Magnesium	Mg mg/L	3.65	4.50	2.30	150.0
12	Manganese	Mg mn/L	1.60	1.40	0.005	0.1
13	Mercury	Ug Hg/L	0	0	0.01	1.0
14	Selenium	Mg Se/L	0	0	0	0.01
15	Sodium	Mg/ Na/L	-	-	-	200.01
16	Zinc	Mg Zn/L	0.90	0.50	2.50	5.0

Sources: WHO (1984); Edo State Water Corporation, Benin City, Nigeria (2017)
Legend: Ug - Microgram or ppb: Mg- Milligram or ppm.

Tables 6, 7, and 8 show the results of the chemical and microbiological tests of the three surface water resources carried out at the Water Laboratories in Benin City, Nigeria. Sample A is extracted from River Ebute which is the downstream of River Ibiekuma while Sample B is derived from River Ogedekpe. Sample C is rainwater obtained from the surface water tanks. The chemical analyses show that aluminium, arsenic, barium, berglium, cadmium, calcium, chronium and copper exist in acceptably utilizable state in conformity with the WHO's standards. The iron quantities in Rivers Ebute and Ogedekpe are higher than the WHO's standard at 0.3 against 3.99 and 3.50. Manganese is also fairly high in the surface river waters. Iron exists in normal state at 0.05 in the rainwater. Lead exists in acceptable state in river waters but higher in rainwaters with a low value of 0.01. Mercury, selenium, sodium, zinc, chloride and cyanide are virtually absent in the three surface waters. Also, nitrates, nitrites, sulphates and sulphides exist in acceptable standards. The pH value of the surface waters is acceptably normal. Microbiological tests show the existence of coliforms in the river waters but these bacteria are absent in rain waters. Climatic forces, seasonal over flooding, contacts with the humans and animals, and periodic leaf decay are accountable for their presence in the river waters.

Table 7. Chemical Parameters of Water Samples A, B, C and WHO's Drinking Water Standard

S/N	Parameter	Unit	Sample A	Sample B	Sample C	WHO's Limit
1	Chlorides	Mg Cl/L	9.50	8.90	14.05	250.0
2	Cyanide	Mg Cn/L	-	-	-	0.1
3	Fluorides	Mg G/L		-	-	1.5
4	Nitrates	Mg NO_3/L	2.05	2.50	0.2	10.0
5	Nitrites	Mg NO_2/L	-	-	-	10.0
6	Sulphates	Mg SO_4/L	3.42	3.65	2.5	400.0
7	Sulphides	Mg SO_3/L	-	-	-	0
8	Total 'drims'	Ug/L	-	-	-	0.03
9	Total 'ddt'	Ug/L	-	-	-	1.0
10	Hydrocaution	Mg /L	-	-	-	0.1
11	Amonic Detergent	Mg/L	-	-	-	0
12	pH	-	6.6	6.9	7.2	9.2
13	Total dissolved solid	Mg/L	-	-	-	1500
14	Total Hardness	Mg/L	-	-	-	500
15	Akalinity	Mg/L	-	-	-	500

Sources: WHO (1984); Edo State Water Corporation, Benin City, Nigeria (2017)
Legend: Ug - Microgram or ppb: Mg- Milligram or ppm.

Table 8. Microbiological Parameters of Water Samples A, B and C in Ekpoma

S/N	Parameter	Unit	Sample A	Sample B	Sample C	WHO's Limit
1	Total Bacteria	Count/ml	0	0	0	100
2	Coliform	Count/100ml	8	6	0	0
3	E. Coli	Count/100ml	0	0	0	0
4	Salmonella	Count/100ml	0	0	0	0

Sources: WHO (1984); Edo State Water Corporation, Benin City, Nigeria (2017)

4.4. Environmental health effects of surface water use in Ekpoma

Both sachet and bottled water production factories exist in Ekpoma. These factories obtain natural water from Rivers Ebute, Ogedekpe and boreholes for public water production. Field surveys of six of these water factories revealed that at the water production stages, chlorine, lime and soda ash were applied for water purification. Fundamental surface water purification methods which include sedimentation, filtration, coagulation, coppering and fluoridation were sidelined. This suggests that the surface water which is sold to the urban residents in the study area for different uses lacks complete chemical and microbiological purifications. Also, the residents buy drinking water directly from the water tankers and pick-up trucks. The two rivers in Ekpoma and boreholes at Irrua provide the water sources for these vehicles. However, these sources of water supply are not purified for residential and public consumption. The effects are shown in the current water-borne, water-washed and water-

Table 9. Water-Related Diseases Prevalent in Ekpoma, Edo State, Nigeria, Based on Hospital Records

S/N	Name of Hospital	Water-Related Diseases in Hospital Records in Ekpoma
1	Ujoelen Health Centre	Malaria, typhoid fever, amoebic dysentery, trachoma, cholera.
2	Uke Health Centre	Malaria, typhoid fever, cholera.
3	Blessed Medical Centre	Malaria, enteric/typhoid fever.
4	Eromosele Medical Centre	Malaria, typhoid fever, gastroenteritis.
5	General Hospital, Iruekpen	Malaria, typhoid fever, gastroenteritis.
6	Eguavoen Medical Centre	Malaria, typhoid fever, diarrhea, cholera.
7	A.A.U Health Centre	Malaria, typhoid fever, amoebic dysentery, cholera.
8	Faith Medical Centre	Malaria, typhoid fever, gastroenteritis.
9	Oriafo Memorial Hospital	Malaria, typhoid fever, amoebic and bacillary dysenteries.
10	Ofure Clinic and Maternity	Malaria, typhoid fever, amoebic dysentery, diarrhea, ringworm.

Source: Field Surveys, 2017.

induced diseases which affect the urban residents. These diseases include diarrhea, trachoma, malaria, typhoid fever, amoebic dysentery, cholera, ringworm, bacillary dysentery and gastroenteritis. Direct discussions with some Heads of Hospitals/Medical Centers in Ekpoma confirmed the presence of these water-related diseases. Randomly sampled hospital records shown in Table 9 also confirmed the existence of these nine water-induced diseases in the settlement.

5. Findings

The study shows that the settlement is sited on the summit of a virtually flat-undulating Esan Plateau which is deficient in huge subterranean water retentive aquifer. It also shows that the settlement lacks a range of vital highlands which could serve as retentive viable catchment basins for the formation of several surface rivers and springs.

It identifies rainfall, borehole, public faucet and rivers as the main sources of surface water resources in Ekpoma, Nigeria. These surface water resources extracted by the urban residents and stored in bowls, plates, drums, dug tanks, engine trucks and plastic tanks are used for domestic, institutional, agricultural, industrial, and research activities by the urban residents.

The study observes that adequate surface water of standard quality is oftentimes inaccessible to the urban residents for different uses owing to limitations posed by poor road surfaces, inadequate funds for maintenance of public faucets, failed power sources for water extraction, increased fuel price, inefficient management, absence of specialists, inadequate water trucks and tankers, and pervious catchment basins.

The settlement receives adequate rainfall on a yearly basis because of its double rainfall-cycle spurred by effective radiation, warm maritime winds and suitable operations in the lower troposphere. This rainwater is inadequately extracted, inefficiently stored, and poorly conserved for human consumption and allied uses.

The study shows that three surface water samples were tested at the water laboratories to ascertain their chemical purity and microbiological safety. Sample A is the water extracted from River Ebute which is the downstream of River Ibiekuma, Sample B represents the water derived from River Ogedekpe, and Sample C is the rainwater stored in surface plastic water tanks.

The chemical analyses show that aluminium, arsenic, barium, berglium, cadmium, calcium, chromium and copper exist in acceptably utilizable state in the three surface water resources in conformity with the World Health Organization's standards. Mercury, selenium, sodium, zinc, chloride and cyanide are virtually absent in the surface water resources. Also, nitrates, nitrites, sulphates and sulphides exist in acceptable standards. The pH value of the surface water resources is acceptably normal. The microbiological analyses show the presence of coliforms in the two surface rivers. This suggests that climatic forces, contact with the humans, animals and micro-organisms and seasonal leaf decay are responsible.

The study reveals that persistent use and consumption of untreated river and borehole waters by the residents have caused the prevalence of water-borne diseases as trachoma, cholera, malaria, typhoid fever, ringworm, dysentery, diarrhea and gastroenteritis in Ekpoma.

Of the three surface water resources assessed in the settlement, the rain water only was found free from environmental pollutants. Before drinking it and to sustain a healthy public life in Ekpoma, the rain water should be carefully boiled and filtered using suitable apparatuses of approved standard.

6. Recommendations

The study observes the existence of an undulating plateau on which the settlement is sited. This scenery is suitable for the construction of over-head, surface, and underground water storage tanks for current and future water uses. Adequate state funding, efficient management, supply of suitable equipment, community support, infrastructural maintenance, routine surveillance, and adequate security provision are required to achieve these water projects.

The state government should construct new roads to link up quarters of water surplus with the quarters of water deficit. Adequate funding, daily surveillance and maintenance of the roads are necessary. The funds should be provided by the state government while the daily sanitation, surveillance and maintenance should be executed by the local government authority. This act of road maintenance must be a permanent task. The services of civil and structural engineers, architects, hydrologists, climatologists, economists and local workmen are required in this regard. Weather predictions with interests on torrential rainfall, intensity, distribution and run-off which could trigger the evolvement of potholes and ravines on the road surfaces must be carried out by the urban climatologists. Of the roads constructed, a distinction must be made between the highways which could carry heavy duty vehicles and the state roads which are essentially suitable for minor water tankers, trucks and cars. The essence of this distinction is to achieve double protection and extension of the life span of the state roads.

Authentic catchment basins should be explored and identified in Ekpoma. These basins are run-off infiltration, accumulation and retention sites which are suitable for construction of viable boreholes and artificial wells. Geophysical, seismic and remote sensing surveys would help ascertain the actual water retentive capacities of these sites. Where the surveyed reports are favourable, new boreholes and wells which waters must be purified should be constructed to match the population strength of the settlement. Different levels of public faucets should be established on the surfaces of the basins to make water extraction easy and timely by the residents. Automatic water tankers and allied trucks driven by certified drivers of humble integrity should be acquired to extract and convey clean water for even distribution to the various quarters in Ekpoma. Subsidized payments must be made by the residents to extract water from the tankers in this regard. Adequate security, sustained surveillance, sanitation, and routine maintenance of the water facilities anchored on timely funding by the state government are strongly needed at these water collection sites. Mechanical and electrical engineers, hydrologists, climatologists, geologists, economists and public relations experts should be deployed to these sites to provide skilled services. Reciprocal remunerations would have to be given to these experts in time.

Ekpoma had a very smooth network of durable roads in the past. These roads were properly maintained by the local and state governments then until recently when 'the change for negligence of maintenance culture' emerged in Nigeria. Construction of new roads and sustained implementation of road maintenance measures are necessary in the settlement. A committee of experts must be appointed to manage these measures in time.

Adequate chemical and microbiological purifications of surface water resources should be carried out by contracted specialists in the settlement. On this note, functional water treatment facilities should be acquired for use at the sites of these surface waters. These measures would help prevent water-induced diseases as trachoma, diarrhea, dysentery, cholera, malaria and gastroenteritis in the residents. However, the residents affected by these diseases should seek direct medical treatments at the hospitals and medical establishments shown in Table 9 at reduced cost borne by the local government. Consequently, a very healthy people would be recreated for purposeful development at the grass root, state, regional, national and international levels.

Standard house designs which embellish adequate channeling of meteorological water into surface and beneath water tanks are needed in Ekpoma. These provisions would reduce the amount of surface run-off which causes potholes and ravines on the road surfaces. Also, covered underground channels should be constructed to collect, connect, and direct surface run-off into some identified catchment basins in the huge settlement.

All the water packaging materials such as factory machines, workers' clothing, bowls, cups, filters, floors, sachets, cans, and plastic bottles should be cleaned holistically to avoid infiltration of impure substances into treated water. This packaging activity requires diligent monitoring, detection, coordination, and supervision by the management of water factories in Ekpoma.

There should be extensive placement of vegetations particularly protective grasses and medium-sized, broad-leaved trees on the surfaces of catchment basins to ward-off excessive evaporation and gusty destructive winds which could impact the water discharge facilities. These vegetations require monthly pruning by the gardeners to maintain normal hydrological standards. Above all, regular environmental sanitation of the settlement using modern equipment is necessary. This act of sanitation would keep the town clean, prevent reckless dumping of hazardous wastes on the surface and eliminate filthy water sceneries which breed water-related diseases.

Above all, it must be mentioned that sustained access to clean and purified surface water resources for direct human consumption, domestic chores, agricultural, institutional, industrial, and research uses, including environmental sanitation is essential to a healthy public and the overall well-being of the immediate community.

7. Limitations of the study

This study which is hydro-climatic and medical geographic natured in contents, identified, inter-alia, nine water-borne diseases in Ekpoma, Edo State in Nigeria (Tables 1, 2, & 9). These diseases were fundamentally induced owing to persistent use and direct consumption of inadequately treated clean surface water resources by the urban residents. Of these surface water resources, rain, borehole and public faucet waters were the most available, easily affordable and often time consumed by the residents. Based on this holistic background, and for further research, this current study suggests profound assessments of the diverse signs and symptoms of these nine identified diseases through careful clinical diagnoses of affected residents by trained medical personnel resident in the study area. Premised on the clinical reports, permanent treatments of the residents would be realized. Although the study area's map showing the river networks is omitted in the study, this act is strictly functional because the reconnaissance and field surveys showed rain, borehole and public faucet waters as the most important, adequately available and easily accessible by the residents. River water is only one source of water among other essential surface water sources identified in Ekpoma, Nigeria.

8. Summary and conclusion

This study examines surface water use and its environmental health effects in Ekpoma, Nigeria. It observes that rainfall, borehole, public tap and rivers constitute the sources of surface water resources which are extracted, stored and used for domestic, agricultural, institutional, industrial, and research activities in the settlement. However, owing to limitations posed by poor roads, few water tankers, failed power, inadequate funding, obsolete equipment, absence of specialists, inadequate water purification, increased fuel price, and inefficient management, the urban residents do not have adequate access to clean and safe surface water resources for utilization. These setbacks led to water-induced diseases as trachoma, ringworm, malaria, cholera, dysentery, typhoid fever, diarrhea and gastroenteritis in the residents. Based on this situation, the study suggests that purified surface water resources should be provided for the residents' use to ward-off these water-induced diseases in Ekpoma. This measure would be achieved through sustained environmental sanitation, construction of weather-resistant roads, acquisition of standard water extraction and purification equipment, adequate state funding, maintenance of water facilities, effective security provision, channeling of rain water into surface water tanks and surface run-off into natural and built ravines, placement of grasses and medium-sized trees to serve as efficacious shields on the surfaces of catchment basins, and deployment of efficient human resources to manage the entire surface water resource facilities in the settlement.

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