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Engineering strategies towards the cataclysmic impacts of Urbanisation on water resources sustainability

Obi Lawrence E *

Dept. of Civil Engineering, Imo State University, Owerri, Nigeria.

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Abstract

This research deemed it necessary to investigate the cataclysmic effects of urbanization on water resources because of the indispensability of this natural resource to the existence of human life. Urbanisation geared up activities which created challenges such as population explosion, high rate of crime, increased temperature, global warming, scarcity of water supply, flooding, erosion, energy supply crisis, steam/river extinction and increased waste generation. Water resources are adversely affected in many forms and dimensions and this work was able to evolve engineering strategies which when applied can improve the water resources and enhance its sustainability capacity. The research opined that the construction of incinerators, landfills and waste stabilization ponds, drainage channel development and adjustment, effective water management, small hydropower stations, structural delineation of green belt and ripararian zones and construction of retention ponds will go a long way to place the water resources in the urban cities on a sustainable path. These measures and approaches have the capacity to curb and /or bring the cataclysmic effects of urbanization on water resources to the barest minimum.

Keywords: Urbanization; Water resources; Sustainability; Green belt; Drainages

1. Introduction

Urbanization is the process through which cities, towns, and communities transform into urban areas. It is a process that imbues cities the characteristics and attributes of growth and attract greater percent of the population coming to live with them. An urbanized city possess a lot of houses, offices and infrastructure, social amenities and a lot of peopleinhabit and work in it. Urbanizations depict the rise of the degree of population that lives in the city and its size. Urbanization comes with good effects such as improved life style and pattern, increased amenities, public utilities, presence of industries, enhanced employability, job opportunity, wide spread transportation etc.

But urbanisation has its side effects and negativities which transcends from environmental pollution increase, population explosion, enhanced waste generation, undue pressure on water and electric power resources system, increased crime and lawlessness, road accident, decrease in agricultural activities food production traffic congestion flooding erosion menace, air pollution to insecurity. The unnecessary demands placed on the basic needs of life arising from population pressure on them created a messy and complicated problems which are commonly associated with urban towns and cities. In view of the dicey nature of these problems, a holistic approach should be adopted in addressing them. This research work however, is filling the gap of how engineering approaches, solutions and strategies can be applied in mitigating the numerous problems created by urbanization. Engineering strategies are appropriate in creating sustainable solutions. The water resources are observed to be most hit in terms of problems created in urban cities and towns. This research therefore is poised to developing strategies through which the problems in the water resources sector could be solved without compromising sustainability

*Corresponding author: Obi Lawrence E
Dept. of Civil Engineering, Imo State University, Owerri.

1.1. . Sustainable urban management

According to the United Nations Population Fund, the world metamorphosed into an important phase in 2008 when more than 50% of the global population (calculated to be 3.3 billion people) are living in the urban areas. This is the first time this development has arisen since the history of the planet earth. With this it was projected that nearly five billion people will be living in the urban cities by 2030. This will mostly affect Africa and this project should be more real in Africa and Asia where urban population will be expected to double between 2000 and 2030. Urban cities are the major culprits in the environmental destruction seen in modern civilization and even with this, policy makers and stake holders attach much attention and preference to increasing urban cities. Sustainable urban development should be the concern of experts and policy makers as this is the only way to guarantee preservation of lives and the entire biodiversity. Sustainable Urban development can be defined as protection and preservation of the cities and its contents for posterity and at the same time ensuring economic social and environmental harmony.A continuous increase in the wellbeing of urban cities with a harmonized functional social, ecological, and economic systems which will guarantee the high standard of life for up-coming generations should be target of policy makers.The realization of urban development sustainability is possible when adequate attention and focus is directed towards such major areas such as urban form, transportation energy and waste management. Urban form is used to describe the type and distribution of infrastructures in an urban city such as roads and buildings and these are key instruments that influence and affect the standard of lives in such cities. The geometric design of roads and its network affect immensely the quantity of fuel which can be used to transverse from one part of the city to another and to a large extent, energy used especially when the energy source is from fossil fuel. This contributes immensely to the generation of greenhouse gases which are inimical to the environment including the water resources. For instance when there is unabated rise in temperature in a city due to climatic change there will be continuous evaporation (loss of water) from the water bodies. Lack of sustainable urban development leads to urban sprawl which leads immensely to loss and disruption of land mapped out for agricultural activities, green belt areas, natural habitats, water and air quality Urban city sprawl has a lot of dements which includes increased transport time and cost, traffic congestion, increased population, infrastructure depletion, destruction of agricultural lands and much pressure on available water supply systems. The increased number of population living in an urban city creates undue pressure on the transportation systems. When a city is more spread out, the people will travel longer distances to meet the basic needs like shopping and going to work places. Invariably increased reliance and dependence on automobile as the most preferred way of commuting increases the pains of commuters.. In view of the danger posed by the use of fossil fuel, it is advisable to engage in a paradigm shift to the use of renewable energy which does not generate greenhouse gasses. Waste generation per capita is affected by some major factors which demographic characteristics such as household size, age structure and yearly income of population. People that live in a yard generate less waste per capita than people that live in a single family as people that live in a common yard control their waste generation more than people that live in a single family house.

Urban sustainability can be achieved by the followings:

- Comprehensive transportation strategy
- Municipal vehicle fleetefficiency
- New and redeveloped building energy efficiency.
- Small scale and localized renewable resources [1].

1.2. Millennium development goals

In the year 2000 in the United Nations Millennium Summit, world leaders agreed to setting time-bound, measurable goals and targets for combating poverty, hunger disease, illiteracy and environmental degradation Discrimination against women was placed at the heart of the global agenda, The outcome of the summit is summarized in what is now called millennium development goals (MDGs). The eight MDGs aim to improve human well-being by ensuring environmental sustainability and by ensuring global partnership. Under each of the MDGs, countries have agreed that targets would be achieved in 2015. Many countries that had serious challenges in achieving this, were mainly countries facing the greatest challenges of environmental degradation [2].

1.3. Water resources

Water abounds in and on the earth. Water resources come in the forms of ground water, lakes, rivers, streams, springs, seas and oceans. They play significant roles in the sustainability of the environment. Water resources form a significant part of the planet earth and they are summarized as hydrosphere in geological studies. The hydrosphere is described as the entire amount of water present on or below the earth surface. It is made up of four important constituents such as water in oceans or seas, water contained in rivers or lakes, frozen water in form of glaciers and ground water found below the ground surface. The five major oceans of the world are Pacific, Atlantic Indian, Antarctic and Arctic oceans

and their associated seas and bays contain about 95% of the hydrosphere. They occupy about 70% of the globe. The presence of the atmosphere and hydrosphere are the most unique feature of the planet earth. To a very large extent, they contribute significantly to the making of life possible on planet earth. [3].

Water has a far reaching importance which ranges from health improvement, industrial development, hydro-electric power generation, agricultural development, recreation to navigation and it possesses the potentiality of sustaining the existence of the fauna and flora on the earth. It is obvious that direct consumption of water of water by plant and animals is top among other uses of water. Water has other important roles and functions such as being used for washing, transportation, recreation, industrial applications, chemical uses, fire extinguishing mechanism, electric power generation etc [4].Experiences have started to emerge on the proof of the extent of extreme degradation of the water resources of the earth. Due to eutrophication, dumping of refuse in water bodies, discharge of industrial waste, etc. many water bodies have suffered immeasurable degree of dilapidation leading to their extensions and death of aquatic animals inhabiting in them. Scientific effort has been intensified and understanding has increased yet much remains to be done. The very visible collapse of fishing stock around the world has helped to direct a little political attention to oceans in general and fisheries in particular. More commitment should be made at both international and national level to adopta more veritable sustainable water resources engineering practice which must include encouraging and enabling sustainable fisheries, limiting pollutions and establishing systems of marine protected area. In developing countries, most of these measures are in their embryonic stage. Water withdrawals from rivers and lakes have doubled since 1960 [4].

1.4. Ripararian & green belt areas

Ripararian and green belt areas in urban towns and cities are expected to be preserved to serve as a balance to the ecosystem. Green belt is an area of open land around a city on which building is restricted. Green belt is also an area of land with fields or parks around a town or city. Some green belt land is indeed aesthetically striking. The green belt is a positive planning of an urban city. It stops urban sprawl and encourages the vital regeneration of our cities, green belt, like green infrastructure in urban areas, reduces the heat island effect of major cities and can provide a cooling function across much wider areas .Green belt areas can provide adsorbent buffers around our towns and cities. Green belts establish a buffer zone between urban and rural land, separating town and country and preserving land for forestry, agriculture and wild life where environment conditions can be improved and conservation enhanced. It is expedient that he green belt lands should be forested but owing to urbanization pressure there is a ugly tendency for these areas to be deforested. This negates and removes the advantages derivable from the intents of the green belt philosophy. The deforestation of the green creates unabated heat within the urban cities and towns and can expose and make the inhabitants vulnerable to heat related diseases.

Ripararian areas are the banks of rivers, streams, seas and oceans and naturally have a particular scenery of forests and in some cases, rocks. These forests or rocks in the banks of rivers and other natural water bodies provide protection and support to the rivers. Deforestation of these ripararian areas can lead to the extinction of the river concerned and such deforestation causes the erosion and flooding of the banks. Forest ecosystems provide an array of beneficial services arising from ecological functions such as nutrient and water cycling, carbon sequestration and waste decomposition plant. Forests are important in moderating local, regional and national climate conditions. Biological disposition are also of vital importance in protecting watersheds, buffering ecosystem against extremes of flood and drought and maintaining water quality. Forests are places of exceptional scenic beauty and provide tourism areas where people can be for wild life viewing and birds watching.

Forests are regarded as carbon sink. They take carbon dioxide and convert it to wood, leaves and roots. They are a carbon source. They release stored carbon into the atmosphere when they decompose or burn. Due to this ability of absorbing carbon dioxide and releasing the same, forests have a significant place in the carbon cycle. Large –scale forest harvesting can have noticeable impact on hydrology and water resources. Large amounts of water are returned into the atmosphere by the trees through the process of transpiration and evaporation (evapotranspiration).

2. Challenges of urbanisation

The challenges of urbanization are regarded as the problems of urban cities and towns. The challenges of the urbanization are logs in the wheel of progress to sustainable urban development. Sustainable urban development is the enhanced well-being of cities or urban regions, including integrated economical, ecological and social components, which will maintain the quality of life for future generations. The various challenges of urbanization generally include urban form, transportation, energy use, waste management, urban heat island effect, water resources system degradation, flooding, human induced hazards, climate change and urban forms constitute a big challenge and can lead

to the creation of complexities. Urban form is defined as the type and distribution of infrastructure like buildings, roads, etc in communities and stands as an indisputable factor influencing environmental quality in cities. The urban sprawl is responsible for the loss and disruption or degradation of adjacent agricultural land, environmental sensitive areas, wildlife habitats and water and air qualities.

2.1. Traffic congestion

The issue of traffic congestion within the urban cities is a major challenge that leads to the waste of travel time and delays in trips which obliterates transportation system sustainability. Several variables reflect energy used in transportation in urban towns in terms of distance travelled, vehicle loading and vehicle mode. The fact that vehicles are major contributor to greenhouse emission makes the issue of traffic congestion a challenge and a key player in global warming. A typical instance is how the configuration of roads and transportation networks affect energy use on transportation trips within the urban cities. Energy use by both transportation and buildings become a principal contributor to greenhouse gas emissions [5.6].

2.2. Increased waste generation

Waste management is a monster that is eating up the residents due to population explosion. Many factors affect per capita amounts of waste generation. For residential areas key factors are demographic characteristics such as household size, age, structure and annual income as well as type of dwelling and geographical location. The presence or absence of waste collection strategies create the amounts of wastes that are improperly disposed in the urban cities.

2.3. Urban heat island effect

The urban heat island effect is another challenge created by urbanization especially when the green belts are absent. This effect occurs as a result of increased temperature in core urban areas relative to the surrounding areas. Such effects can be effectively reduced by the establishment of green areas due to their cooling effects. Higher temperatures created by the urban heat island effect can also generate smog and enhance ground-level ozone. The smog and ozone can drift to nearby areas and in some cases can reduce agricultural productivity, increase health risks and even trigger tornadoes and thunder storms. The urban heat island effect is one problem that led to development of green roof technology which involves creating a new or retrofitting an existing roof with a growing medium by allowing plants, shrubs, or trees to grow on the roof [1].

2.4. Vulnerability to disasters and hazards

Urban areas are more susceptible to the natural and induced hazards due to increased population. Owing to rural-urban migration syndrome, there exists a grave need to construct buildings and in the quest to have these buildings constructed under emergency condition, poor construction may creep in and such buildings are liable to collapse. The pressure of too many people can subject buildings to be used for a wrong purpose which runs contrary to the standards of the initial design. Urban cities are vulnerable whether it is naturally – initiated or humanly trigged hazards. United Nations Environmental Program has discovered that 75% of global population lived in areas affected by natural disasters before 1980 and 2000. Geographically hazards such as earthquakes have been constant over the past 50 years and weather associated hazards have increased greatly. It has been noted that population growth, urbanization, environmental degradation, increased mobility, ageing infrastructure, etc have been identified as major causes of natural or induced disasters[1].

Urban cities are vulnerable to some humanly and naturally induced hazards due to high concentration of human population and poor condition of building structures. The number natural disasters are more frequent and also more severe in urban cities. There are more reports of building collapses in urban cities like Lagos and Port-Harcourt in Nigeria than observed in the rural areas.

2.5. Population increase

Incessant population increase arise from migration of citizens from the rural areas to the urban cities. There a lot of attractions that motivate people to move from the rural areas to urban cities and some of these attractions include employment availability, presence of amenities, better condition of living, improved infrastructure, etc. Citizens move to urban cities because of the impression that there are available job opportunities in the urban cities. Due to the desire to fill these job opportunities, citizens troop en mass to these urban citizens. This tremendously increases the number of citizens that migrate to the urban citizens. Often than not, the job seekers who migrated to the urban cities discovered to their chagrin that the expected jobs are not truly available as anticipated.

Population is a global variable that contributes and makes significant impact on the interaction of the various subsystems within the planet earth. According to these interactions, the interest is on the impact the interactions will have on humans or Homo sapiens as a sub system. Population increase has affected global energy consumption and had made it to increase twelve times between 1850 and 1970 while the population tripled. There are 7 billion humans gasping and struggling for sustenance on the planet earth [2, 3]. The different trajectories of developed and developing countries are epitomized by Nigeria and Japan. In Japan, the birth rate works out to slightly more than one child per woman. Fourteen percent of Japanese population is younger than 15 years and twenty one percent of the Japanese population is older than 65 years old. Comparatively, forty-four percent of Nigeria's population is younger than 15 years with only 3 percent over 65 years. A typical Nigerian woman gives birth to six children in her lifetime. The population increase inflicts much pressure on the carrying capacities of the urban cities in the areas of water demand, exploitation and exploration. The pressure creates water scarcity, pollution of water resources extinction of water resources over exploitation of groundwater with its attendant and dangerous consequences. In 2008, the world reached an invisible but momentous milestone for the first time in history, more than half of its population 3.3 billion people live in urban cities. By 2030, it is predicted that this number will swell to more than 5 billion. Their future, the future of cities in developing countries, the future of humanity itself depends very much on decisions made now [7].

2.6. Energy resources

Energy is society's critical resource, when it is scare and costly, everything we try to do, including growing our food obtaining other resources like fresh water, transmitting and processing information, and defending ourselves, becomes far harder. This definition emphasizes the indisputable position of the energy in the life of man. The availability of the energy resources and its applications makes the urban cities and towns the dream of rural dwellers. Energy is a driving force towards the availability and functionality of industries and comfortable living in urban cities and towns.

Energy resources are considered as renewable and non-renewable. Renewable energy resources are those that can be replenished in a relatively short time period and remains in exhaustible while non-renewable energy cannot be depleted without quick replenishment and it has a conceived negative effect on the environment.

2.7. Water resources sustainability

Water resources sustainability can be achieved through the integrated water resources management. This is water resource management that embraces the holistic approach in water utilization, exploitation and exploration. Consistent with the integrated water resources management (IWRM) is the hydrosolidarity.

2.7.1. Hydrosolidarity

Hydrosolidarity refers to an approach that recognizes the interconnections among aquatic, terrestrial and other resource systems, leading to a management that is integrative, participative, collaborative, coordinated and shared, whether at local, state, national or international levels.

Understandably, the challenges of achieving hydrosolidarity increase when moving from local to international situations. Notwithstanding, the difficulties associated with hydrosolidarity it is most often applied to international rivers or lakes in which sovereign states claim control over the water within their boundaries without regard for implications for countries that share the resource, especially the downstream users [8].

Elements associated with hydrosolidarity reflect the reality of aquatic systems, including that water flows downhill, leading to upstream and downstream interests in a river basin or catchment, interconnections exist between water and land systems, meaning that land-based activates can have significant implications for water quantity and quality,. the multiple uses that water can serve which ranges from domestic uses to crop and industrial production, to supporting migratory bird habitats and recreation, using river basins or watershed as the spatial unit for planning and management, .ensuring attention to upstream-downstream issues, recognizing the interrelationships among water, land and other resource systems, engaging a range of stake holders in a collaborative and participatory manner and finally acknowledging the needs of biophysical systems as trendy with the integrated water resources management (IWRM). The Global Water Partnership defined IWRM as a process which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. The uniqueness of integrated water resource management is to overcome the challenges resulting from various groups having interest in and organizations being responsible for water and related resources, along with the reality that they each often focus only on their own interests and responsibility. Integrated water Resources Management move managers to consider integration of several

levels including integration of various dimensions of water, such as quantity and quality, surface and underground and upstream and downstream.

The use of river basins or watersheds for planning and management is recognized as the most appropriate spatial unit to achieve this integration of water considerations with those for terrestrial and other related resources. This involves recognizing that many water problems, such as pollutants or flooding, originate from or are exacerbated by land – based activities. Here also river basin or watershed is seen as the most appropriate unit to facilitate attention to a range of interconnected resource systems. Integration of water, as a part of the environment system, with aspects related to economic and social systems is vital.. Regional land – use planning, environmental impact assessment and strategic sustainability assessment are used to connect environmental economic and social considerations. Water has been attracting increasing attention. Owing to regional water experience, some suggested that in the twenty first century, it will represent what oil did at the end of the twentieth century as a strategic resource. Some has gone further, suggesting regional wars can be expected as a result of water shortage. Whether armed hostilities or non-armed hostilities may erupt over water, it is pertinent to note that water is a necessity for human life. There is no substitute to this fact.

2.7.2. Water Ethics

Furthermore, many needs and interest compete for this resource. Given this fact, it is puzzling that much attention has not been directed to the evolvement of water ethics to establish principles on which water management decision could be predicated. UNESCO has published some relevant reports but the study that focused on water ethics has been paltry. However, there were few works that addressed the problem of water ethics and the following statements are based on such research. They maintained that ethic normally is a statement of principles or values to guide behavior by individuals, groups, or professionals.

Mathew, Gibson and Mitchell (2007), offered six imperatives for a new water ethic and they include

- meet basic needs to enhance equity today and for the future
- safeguard ecosystems by allocating sufficient water resources
- encourage efficiency and conservation of water resources
- establish open and participative decision making processes
- respect system complexity and emphasize precaution
- seek multiple sustainability benefits from water centered initiatives

The first imperative of the water ethics has been taken up by United Nations Human Rights Council as they have made water and sanitation to be recognized as a basic human right and has established an international monitoring organization to track the actions of nations [9].

2.7.3. Water Supply Management

Water stress can be reduced through many approaches. The most common approach is the supply management and demand management but an emerging approach called soft path proved to be useful. Water supply management is the traditional approach applicable mostly when water shortage is anticipated. Water supply management approach involves the development of new source of supply and this can be accomplished through either augmenting an existing supply for example raising the height of a dam in order to impound more water or developing entirely a new supply system like constructing a new dam and reservoir, new wells or connecting a new pipeline to transport water to the desired location as a form of augmentation or new supply. The connection can be made to a river, lake or desalinization plant. The rationale is for the approach is that population will grow and the economy will expand and each requires additional water supplies. Without incremental water human well being will be impeded. Supply management approach is water supply augmentation done through the mobilization of more resources ike capital – intensive projects; effort to conserve water or redefine allocation to users. All these options have political and financial implications and they come with risks, costs and benefits. The private or public sector strongly shape what solutions particular stakeholder is likely to pursue for and undertake [10].

2.7.4. Water Demand Management:

if the basic approach to supply management is to manipulate the natural system to create new sources of supply, the approach of the water demand management is to influence human behavior so that less water is used then existing sources or available water may satisfy demand for a longer period of time. Many methods abound for influencing human behavior in water and the commonest of them is to use pricing which sends the signal to water users that if they use

less water they save money. The best way to achieve this is to introduce water meter in households and industries. High pricing of water may make it difficult for low income earners to pay for water and in order to avoid this, social welfare policies can be instituted to ensure that vulnerable people are not in jeopardy. This is very important for water because water has no alternative [11, 12].

2.7.5. Soft Path Management

The soft path management approach is the extension of the demand management approach. Soft path aims at improving water use efficiency but goes farther than demand management by challenging basic patterns of consumption. In their view, demand management emphasizes the question of "how" to do same with less water. In contrast, the soft path management approach addresses the question of "why" or why water is being used for a particular purpose. The why question normally leads to consideration of broader range of method. Brandes and brooks (2005) provide several examples to illustrate the significance of the "why" question thus; ……why do we use water to carry away waste, demand management would urge low flow toilet but soft-path management would recommend water-less toilet systems are available.

Why do we use half of water in the house for watering lawns, gardens and sidewalks. demand management would urge more efficient sprinklers with automatic shut-offs maybe even more water restrictions. The soft- path management goes further recycling water from bathtubs and washing machines.

The soft management is based on four basic principles which distinguish it from supply management (branches & Brooke, 2005);

- Water is treated as a service rather than as an end in itself. In the soft path, water is not viewed as the final product rather for a few human uses (drinking, washing) and for support of ecosystem. Instead water is viewed as a means to accomplish specific functions including sanitation, farm production oryard maintenance.
- Ecological sustainability is a fundamental criterion. Ecosystems are viewed as legitimate users of water and also as one foundation of economics.
- Quality of delivered water is matched to an end-use requirement. While high quality water is necessary for human consumption, the quality required for water may vary significantly for other uses. The soft path seeks to match water quality to the purpose to accommodate an end use.

Determine the demand future condition and plan back to the present. Conventional planning for water takes the present as its starting point. Future needs are projected and then decisions are taken to meet their needs. The soft path focuses not on the most probable future but instead on the most desirable future [13, 14],

3. Engineering strategies and solutions

In line with this research, the focus is to develop strategies that can enhance water resources sustainability through engineering approaches. Engineering solutions are researched upon and the results are presented as follows;

3.1. Drainage Channel Development and Adjustment

Existing urban towns and cities are highly susceptible to flooding due to the construction of paved roads and family compounds which reduced infiltration and increased surface runoff. The developed more runoff has to be properly managed and discharged through the construction of drainage channels. Rural areas which were emergently turned into urban cities should have their drainage channels adjusted by enlarging their capacities to accommodate the increased runoff. Well-adjusted channels tend to eliminate or minimize too fierce attack of flow thereby curbing, erosion, overflow, backwater effects and flooding. Adequate hydraulic considerations should be given to the design (Obi, 2009). The de-siltation of the drains should form part of maintenance programme, however it should be noted that a well-designed drains have a self-cleansing capacity.

Periodic flooding on streets and other areas of urban setting are due to uncontrollable water flow on the surface of the earth and this has caused a lot of problems to the growth of urban areas. Proper channelization of runoff flood in urban cities will increase the volume of water in rivers and streams which can be harnessed for other purposes within the urban cities.

3.2. Effective Water Management

Urban cities and towns should be provided with efficient and proficient water management. Water resources sustainability can be attained through proper allocations, metering, planning and design, market trend pricing, watershed protection, professional operation and maintenance of water facilities. Sustainability of water resources commences with planning and design through the collection of relevant data and its application for design. Metering of water supply makes water to have value and can be a source of data for projections in water utilization in the urban cities.

The water management approaches such as the integrated water resources management, supply management, demand management, soft path management and the hydrosolidarity should be fully employed according to needs and requirements. The management of water resources should go beyond the traditional approaches of supply and demand approaches. The recent approaches of integrated water resources management, hydrosolidarity and soft path should be engaged as they are more holistic and has the capacity to guarantee sustainability.

3.3. Small hydropower Stations

Small hydropower stations should be established to serve urban cities where there are streams and rivers. This will create and move attention and proper care to our rivers and streams. This can lead to the construction of small hydroelectric power plants and will help most of the rivers and streams to be dredged. It will go a long way to end neglect and abandonment of rivers and streams which is the major reason for their extinction and the wrong usage of river and stream channels as refuse and waste dumping locations. The inadequacy of the electricity generated centrally has adversely affected the urban cities and this strategy of small hydro plants will save me situation. This has become necessary in view of the persistent electric power supply problems which had incarcerated urban cities and the need to satisfy industrialization infrastructural development and the increasing urban population.

3.4. Structural Delineation of Green Belt and Ripararian Zones

The sustainability of water resources can be achieved by putting in place structures that can effectively protect the ripararian zones and the green belt within an urban city. The essence of the delineation is to discourage human interference and intrusion into those areas. The green belt area and ripararian zones help to create balance within the ecosystem and minimize the urban heat island effect which tends to increase the temperature in core urban areas relative to surrounding areas. When the temperature of the urban city rises, there will be unusual evaporation from the water resources bodies within the urban city. The structural delineation of the ripararian zones will protect and preserve the natural landscape of the rivers and streams while that of the green belt area will enrich the aquifer thereby enhancing the groundwater.

3.5. Construction of Incinerator Landfills and Waste Stabilization Ponds

In addition to the 3R strategies/processes of waste source reduction, waste reuse and waste recycling, the construction of incinerator, landfills and stabilization ponds will spare our water resources channels and drains from being converted to a waste disposal site. Incinerators should be sited at appropriate locations, preferably far from residential areas and to avoid ugly health consequences that may arise thereby. Landfills are well designed and constructed areas where solid wastes should be disposed. The landfills play a major role that reduces the indiscriminate adulteration and pollution of the groundwater while the stabilization ponds helps in treating waste water before disposal. Landfills involves disposal of waste materials by burying them especially as a method of filling and reclaiming excavated pits.

3.6. Construction of Retention Ponds

Owing to the poor groundwater recharge and increased surface flooding in urban cities, it will be expedient to design and construct water retention ponds which can allow the collection of water during the rainfalls and allowed to percolate into the ground or be released more slowly. This is most appropriate in urban cities with the problem of urban sprawls, especially when suburbs are built on the surface of aquifer recharge areas such as moraines as thiscan practically affect the amount of water available in aquifers for human use.

4. Conclusion

Urban cities affect the hydrological cycle in multiple dimensions both in quantity and quality of water. In the dimension of quantity, surface water is increased due to the massive construction of road and building infrastructure in urban towns. Road pavements which are impervious with building roofs generate much runoff which can create flooding and erosion if not well handled and managed. The implication is that the expansion of roads and construction of parking lots

result in precipitation running off the surface more quickly, since there will be little or no infiltration due to large expanse of man-made impervious surface. In this case, there will be reduced aquifer recharge and consequently the groundwater will be adversely affected.

The quality of water is also adversely affected because of pollutants such as oil and gas from vehicles infiltrate into the aquifer to pollute the groundwater and also gets into the surface water such as rivers and streams as runoff. Obviously, polluted water resource has far reaching effects on the health of the urban population and other aquatic living species. This observation is in conformity with United Nations Population Fund (2007), which stated that "urban areas can affect water resources and the biological cycle through the expansion of roads, parking lots and other impervious surfaces which pollute runoff and reduce the absorption of rain water and aquifer replenishment".

In view of these negative impacts of urbanization on water resources, this research has succeeded in proffering engineering solutions and strategies which when applied will restore water resources in urban cities to a sustainable path.

Recommendations

Following the results of this research the following recommendations are made;

- Green belt zone and ripararian areas in urban cities should not be destroyed as they act as a buffer to the urban heat island effect.
- Water retention ponds should be constructed in aquifer recharge areas.
- Landfills, stabilization ponds and incinerators should be put in place to complement the strategies of the 3R – reduction, reuse and recycling of wastes.
- Water management should be effectively employed through the approaches of supply management, demand management, integrated water resources management, the soft path and the hydrosolidarity.

Efficient drainage system should be maintained on all the road networks, buildings and parking lots and should be directed to suitable discharge points.

Compliance with ethical standards

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There was no conflict in the course of this research as it was singly authored.

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