SIMULATION OF ENVIRONMENTAL POLLUTION USING ADVANCE TECHNOLOGY AND MODELING

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ABSTRACT

In Khartoum/Sudan the consumption of water per capita in urban areas far below the real need and WHO standard and huge volume of untreated municipal wastes water and industrial waste is discharged directly to an upstream from the town's sewage water and treatment plants. Only 5% of resident received waste water treatment services, and 95% of waste discharge in unregulated dumps and injected into ground, these leading to pollution of the atmosphere, surface and ground waters, and poses a serious environmental hazard downstream. The main objective of this paper to Simulate pollutant produce from water sector demands being prime indicators of water and environment challenge, using WEAP model, and GIS software .

The methodology used in this study to identified appropriate indicators and creates a model that represents water resource status, and pollution generator sectors for a specific system boundary.

Khartoum satellite Landsat Mosaic Image (copy write), and Digital elevation model, (DEM) for Sudan, from Global ESRI map, and Land cover map, acquired from Sudanese remote sensing and seismology authority are used in this study to create maps .

The Basin Catchment model WEAP21 system scenarios with Remote Sensing, and GIS predicted response and evaluated water deterioration risk quantity and quality related to river Nile catchment area in Khartoum. The model software selected provides decision makers with watershed environmental response factors, with allocation for sustainable water concern lower River Nile catchments.

The model approach across user was taken into consideration to ensure withdrawals, assumed improvement in consumption, researcher assumed building a reservoir to improve quality, and reduces people suffering from water shortage, building expansion to reform waste, with reference time from 2015 and projected year by 2030.To fulfill objectives the models was used for pollutant transport from upstream to watershed, to evaluate the effect of applying alternative management practices by development of different Scenarios.

Water quality data are collected from Ground water central laboratories, also from Khartoum state data base center. While Waste water data collected from waste water treatment plants in the towns, and from constructional and environmental laboratories, centre. Also, field samples were collected from discharge point in lagoons near river shore and from the cross point of discharge into the river. The study result show how satellite technology combined with local monitoring, GIS, and advanced modeling system can be used to investigate the improved accuracy of the model results, and to improve operations and performance of service providers downstream. The result indicated that scenarios can be developed to explore options for the future and sustainability, and implication of various policies can evaluated. For environmental carrying capacities, the model results indicated that, 90% of water consuming by sector demands end at the receptors as waste water need to be treated. The pollutant load produced by those waste water treatment plants were measured and simulated including pollutant (BOD, COD, TSS, Phosphate, Nitrate, Total organic carbon, heavy metals (Pb, Cr, Zn, Cu), which in turn affects the quality of water resources available for direct use. The improvements in water collection systems affect water supply and wastewater treatment, while the improvement in waste water treatment plants after built new environmental expansion and technology may reduce the flow of waste water to receptors 50% by 2030. In order to ensure a long term development of water resources, and to avoid water becoming a limiting factor in the development of dependent activities, we recommend that country should develop environmental pollution reform and management policy based on an integrated management which associates management of surface and underground waters, qualitative and quantitative measures and management of use by various water sector.

1. INTRODUCTION

Water pollution refers to a condition of water within a water body caused by the presence of undesirable materials, while contamination is the introduction of substances into water at a sufficient concentration to make the water unfit for its intended use. Atrophic water quality criteria deal mainly with nutrients and Eutrophication status, algae growth (chlorophyll, oxygen balance (%) saturation), nutrient budget (nitrogen, phosphorus levels, and total organic carbon
Calculations for details on the generation, treatment and flow of pollution

TP Return Link Inflow TP, Dest =Treatment Plant Inflow – Treatment Loss TP (1)
The amount consumed in processing, which disappears from the system is assumed to be a fraction of the water received by the treatment plant, this consumption fraction is entered as data
Consumptions = Treatment Plant Inflow TP x Treatment Plan Consumption TP (2)
Where TP mean =Treatment plant)

2. STUDY AREA

Khartoum is the capital of Sudan. It is also a state with an area of 20,970 km2. And population estimated as five millions. It is located at the confluence of the White and Blue Niles,370 meters above sea level known as the "Al-Morgan" latitudes 15º26'- 15º45'N, longitudes 32º25' - 32º40'E. The Nile flow north towards Egypt and the Mediterranean Sea.
Considering environmental pollution generation sector demand, the waste water transportation and division, the urine per person is 400-500 liter per year and stool 50 liter per year, the total needs per person is 15,000 liter of water for transporting. This indicated that there are two ways in Khartoum State to transport domestic and industrial liquid waste. The first is on site disposal, or pit latrines, and remote areas. And second in septic tanks or soak away. The negative environmental impacts with the first type are hazards to soil and ground water pollution, the second convey the waste to treatment plant, which is ideal technique. There is also the grave situation of pollution generation sectors, in urban areas, of the three Towns, Khartoum, Khartoum North, and Omdurman. One of the main problems which face water resources in Khartoum state is the systems of sewage waste disposal which can be classified as :Pits latrines in the form of dug hole (5 to 10 meter) and dug wells connected with septic tanks (more than 20 meter deep) called siphons. Drilling well used for waste storage collection of in-house waste, and industrial waste water, and municipal waste by trucks car and random disposal.
Considering the municipal sewers most of the towns in Khartoum state lack unique waste disposal system. The waste contamination is found attached to big dwelling complexes. Effluent can reach the river where there is improper sewage system. Municipal wastewater consists of sewage effluents; urban runoff drainage, hospital waste, and other collected waste water. No measurement has been carried out for the flow of waste water to identify the waste load. Due to the residential expansion the area was surrounded by new buildings and the waste water increased. The system and all the waste discharged Directly to the river without treatment. Added to this is environmental governance enforce it, general industrial facilities pollution generation from agriculture sector with hospitals hazardous waste not managed

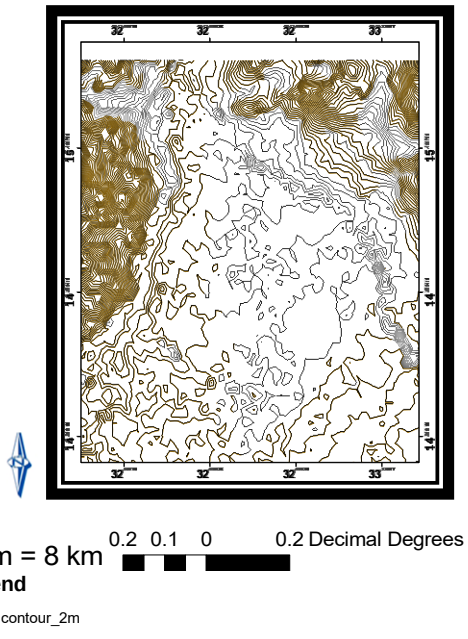

Fig (1) Khartoum Contour map of the study area was produced from the SRTM-DEM
Using the Geo- Special analysis hydro terrain extension link with ArcGis10.2

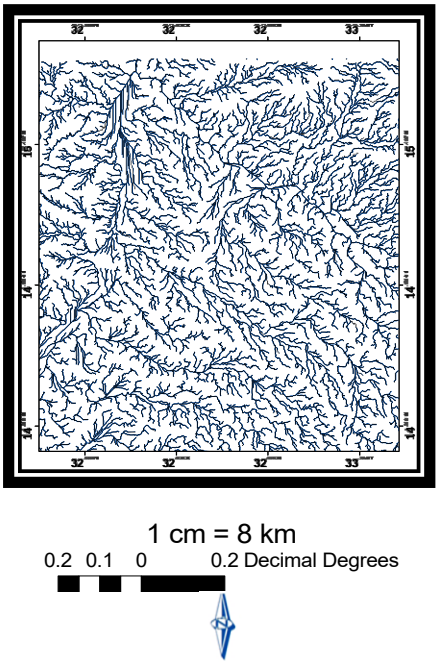

Fig (2) Khartoum Drainage system

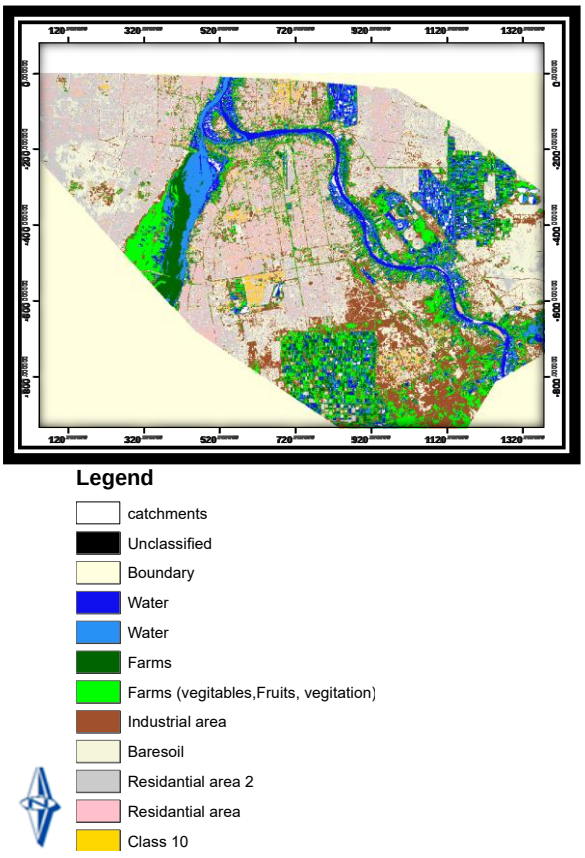

Fig (3) Study Area land use

3. METHODOLGY

This part considered the methodology adopted to conduct the study, climatic data, hydrological year, and Water quality data from Laboratories. It considered the existing situation and pollution sources in the vicinity of Khartoum State. Machines and equipments were used to supplement the research activities. Data collection including data of the Blue Nile, White Nile and the main Nile in the vicinity of Khartoum State were carefully and correctly collected. The road through this section included the other important activities conducted by the researcher. These activities included population behavior and growth in relation to the existing environment through time. The section also covered collection of other key data as well as implementing and suggestion of new developed works. Analysis of Surface, Nile River and ground water samples were conducted in the laboratories using standard method for examination of water and waste water, as well as sewage and municipal waste water (point source) were collected from construction and environmental laboratories center in Khartoum

The Basin Catchment model WEAP21 system scenarios with Remote Sensing, and GIS predicted response and evaluated water deterioration risk quantity and quality related to river Nile catchment area in Khartoum. The model software selected provides decision makers with watershed environmental response factors, with allocation for sustainable water concern lower River Nile catchments.

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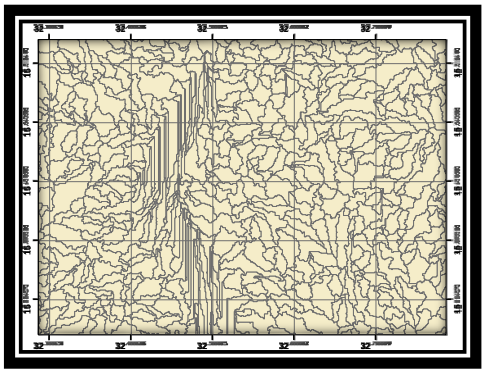
4. DATA COLLECTION AND ANALASIS

Supplies Data are from Rivers, Ground Water, and Storage capacity, maximum Monthly Withdrawal, Natural Recharge and Reservoir. Rainfall data and average monthly stream flows were obtained from Nile water resources management authority,. Baseline data for model calibration, wastewater quality data were collected from Ministry of Planning, (constructional and Environmental labs. centre were used as a baseline for waste water pollution modeling. All the satellite images, maps, and GIS software were obtained from Sudan remote sensing and seismology authority.

Application of WEAP includes several steps, the time frame, spatial boundary, system components and configuration of the problem. The Current Accounts provide a snapshot of actual water demand, pollution loads, resources and supplies for the WEAP system. The Scenarios stimulate creative thinking, e.g. vulnerabilities, pinpoint problems achieving future goal. I The model tree and branches first we created Current Accounts of the water system under study, based on a variety of economic, demographic, hydrological, and technological trends, a "reference" scenario projection was established, referred to as a Reference Scenario, The model was set up for a current account year in 2015 and projected to 2030. It was modeled and evaluated giving consideration for existing and planned developments in relation to current and future water demands among multiple water users, namely Reference: 2016-2030.The Assumed Population Growth of 3% Sudan Census 2008 estimate the number of Inhabitants of Greater Khartoum increased almost eight fold in 38 years from 110 Thousand to 5.3 million, in 2015, this trend is expected to continue with the state's population projected to grow 2.8 % every year. Using more water will help Khartoum state meet water resource challenges of the future.



Fig(4) River Catchment

0.055 0.0275 0 0.055 Decimal Degrees

1 cm = 4 km

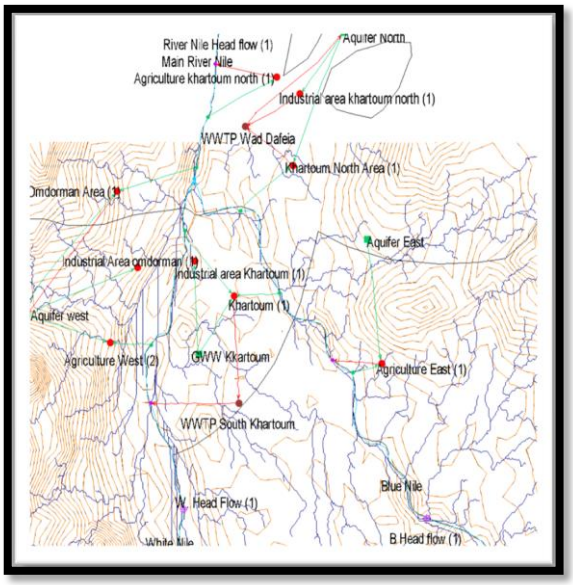


Fig (5) Model Schematic Area (Sector Demands &Supplies

5. RESULT AND DISSECTION

The numeric model data was introduced in WEAP Schematic model diagram. The model verified and calibrated output results in the forms of maps, figures, and tables. In Water utilities the improved accuracy of the model results was presented in Khartoum Digital Elevation Model (DEM).

Space technology is part of promoting and supporting innovation by providing environmental information which can be used to improve preparedness and planning for water utilities and other end users. The result show how satellite technology combined with GIS software, local monitoring and advanced modeling (WEAP) system can be used to improve operations and performance of service providers downstream, such as: Environmental pollution improvement

A. All Transmission link Bm^3

-Return Link Flows, Inflows and Outflows :(fig 6)
-Outflow to White Nile maximum amount 22 Mm3 in November 2016, this amount decrease in the projected year 2030 to 20 Mm3
-Outflow to aquifer north river catchment increase from 250,000 Mm3 in 2015 to 12.5 Mm3 in the projected year 2030
-Outflow to WWTP (Wad Dafiea, Khartoum north) were calculated by the model, the amount found equal to13 Mm3 in year 2015 and in the Projected year 2030.
-Annual Outflow to WWTP (South Khartoum), calculated as 800 Bm3, for reference and projected year 2030

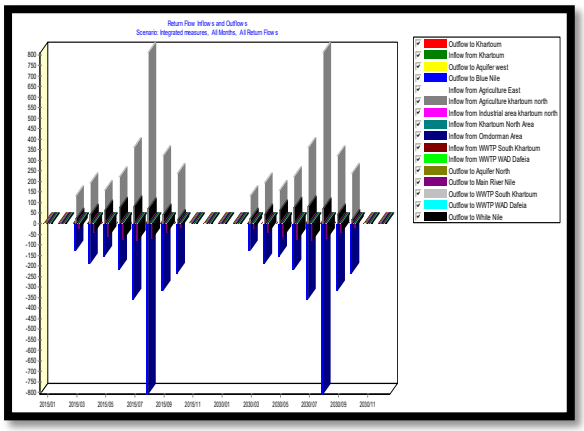


Fig (6) Return flows and outflows, scenario integrated measure

B. Improvement of the Waste Water Inflow and Outflow to the environment (2015-2030) m^3:

Waste water from municipalities and from industries which inflows to receptor WWTPS reduced by projected year 2030 to 11%, lost in treatment 11%, outflow to aquifer north Khartoum with 11%, and outflow to white Nile with 13% (table 2)

Table (1) the waste water inflows and outflows to environment

Table (1) Total Waste Water Inflow and Outflow

Site/year	Sum/2015	Sum/2030	Improved %
Inflow from Industrial area Khartoum north	64,975.90	51,498.90	11
Inflow from Khartoum	124,556.40	95,407.80	13
Inflow from Khartoum North Area	95,701.20	77,242.60	10
Lost in Treatment	-134,769.50	-107,763.60	11
Outflow to Aquifer North	-32,135.40	-25,748.30	11
Outflow to White Nile	-118,328.60	-90,637.40	13
Sum	0.00	0	

C. Improvement of Pollution Load from Soba WWTP to Receptor River White Nile:

At El Dobacen Bridge the pollution load improved and Nitrogen and PO4 reduce by 100%, While TSS reduced 33% by projected year 2030, these improvement may be due to establishment of new environmental expansions, and introduce of new innovated technology for waste water treatment and recycling (Table 2)

Table (2) Pollutant Load from Soba WWTP to white Nile

(WWTP): Waste water treatment plant

Pollutant	Unit	2015	2030	%	pollutant
BOD	Thousand kilogram	205.7	182.2	6	Reduced
TSS	Million kilogram	261.3	131.3	33	Reduced
Nitrogen	Billion kilogram	890.5	0.0	100	Reduced
PO4	Thousand kilogram	934.8	0.0	100	Reduced
COD	Thousand kilogram	480.0	751.4	-22	increased
Pb	Kilogram	2490.0	2700.0	-4	increased
Fe	Kilogram	21513.6	23328.0	-4	increased
Cr	Kilogram	23356.2	25326.0	-4	increased
TOC:	Thousand kilogram	2603.1	2283.7	6	Reduced

6. CONCLUSION

The main objective of the study is to identify appropriate indicator to create a model that represents water resource status for a specific system boundary and also provide GIS maps. This model which is derived from a set of keywords represents the way of evaluation. These keywords are generated from scientific theory. The keywords converted into indicators which show the state or contaminants in surface and ground water. Leaching from septic tanks and hazardous waste landfills as well as land application of bio-solids (sludge) from wastewater treatment plants continue to be important sources of contaminants to groundwater. When wastewater is discharged on these dry lands, it can seep into the underground water tables and well sources. So, appropriate indicators are to be selected to construct a model, to evaluate the water and environmental status. Technological innovation is instrumental in addressing our increasingly complex and multidisciplinary water challenges

In this paper we used WEAP system to study waste water discharge as the primary sources of unregulated pollutants and of water for generations to come, this can render entire water supplies useless for people in multiple locations.

The discharge of waste water into the River Nile has an impact on water quality, while TOC load has not improved mainly from municipalities waste water discharge. The reduction in waste water inflows was equal to 20% by projected year (2030)

The model result indicated that, a number of pollutant indicator were investigated (BOD, COD, TSS, TOC, N2, PO4, and Heavy metal are reaching to surface and Ground waters through the discharge of sewage, urban runoff and irrigation Runoff without treatment. These pollutant loads reduced to 50% by projected year 2030 and waste water quality improved due to introduce of a new environmental built expansion

The model result indicated that, a number of chemicals are reaching to surface and ground waters through the discharge of sewage without treatment, thinking of the rivers receiving the effluent as sustainable drinking water rather than as an infinite dilution system, which forces us to question the practice of discharging waste directly into water supplies. Cheap and effective technology to treat wastewater before discharge and methods to treat before dispose of sludge would help to alleviate this source of contamination.

Space technology is part of promoting and supporting innovation by providing environmental information which can be used to improve preparedness and planning by water authority and other end users. This study show how satellite technology combined with local monitoring and advanced modeling (WEAP) system can be used to improve operations and performance of service providers downstream, such as reservoir managers, water utilities, and environmental pollution reforms

Various allocation scenarios were ranked using the developed toolbox and it was shown that if it is achieved and provided an efficient and high standards treatment then allocation to all different sectors simultaneously or allocation to mastic as the first priority and in favours of agricultural and industrial water demands rank bets in All conditions, it was further shown that this management approach, ensuring a desirable outcome both in terms of quality and quantity, one of the factors that define the road to sustainable development is how water is used and managed.

7. RECOMMENDATION

Use biological treatment method by grow diatom algae in sewage is the best solution to reduce pollutant load, it is a process to grow Diatom Algae in sewage and can avoid sewage polluted the river, Treated sewage with Diatoms can be released into lagoon, and rivers. The fish in the natural water bodies would consume the Diatoms.

-Use Electron Beam accelerator use to reduce color and toxic content in industrial effluent. Irradiation with electron beams breaks down the chemicals into smaller fragments, which makes any subsequent conventional biodegradation treatment more efficient. It means they pose less of a risk to the environment and human health when found in rivers or other water bodies, irradiation does not make the water radioactive. Electron Beam facilities used around the world to sterilize medical supplies, clear food from microbial contaminants

-Recycling waste water to produce bio-gas for energy, and remaining sludge can be use as agriculture fertilizes. While treated water can be use for irrigation

- Legislative acts and regulation for well drilling and proper disposal of effluent is of high importance

-Implementation of Khartoum environmental act of 2008 should be enhance pollution sources should be of proper designs to eliminate infiltration to boreholes through soil layer

-The use of innovative approaches such as Earth Observation (EO) and space technology can enhance water resources data at the national and global scale; however, reliable data on water quality is scarce where monitoring networks and capacity are lacking. Use of remote sensing can provide data from space technology on five surface water quality indicators: turbidity, chlorophyll-a, Harmful Algal Blooms (HAB), organic absorption and surface temperature. It aims to improve water quality monitoring with less times and little cost, and to support the SDG6 implementation

-Industrial waste requires high level of treatment to remove the hazardous toxic materials before being discharged into the environment. So a decentralized system can be used to treated small volumes. A group of industries unit that are located close to each other can apply this method before effluent their waste to the environment

- One way to approach the occurrence of chemicals in waste water, and in the environment in general is to regulate them at the manufacturing stage. Places greater responsibility on industry to control and manage risks and to provide safety information on those substances. Manufacturers and importers are required to gather information on the characteristics of the chemicals they produce and to register the information in a central database

-Amendment of regulations, and establishment of specifications and standards

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REFRENCES

1-APHA, (1998), “Standard Method for Examination of Water and Wastewater”, 20th Edition, US
2-Elraheem, etal, (2016), paper titled “Challenges Facing the Drinking Water Sector in Sudan”, water and sanitation policy, Khartoum
3-Fadl Elmoula (2015) “Report World Meteorological Organization.(UN) [14], presentation, (NWC). Khartoum
4-Khandake IftekharulIslam, (2015), "A Model of Indicators and GIS Maps for the Assessment of Water Resources”, department of Civil Engineering, IUBAT University, Dhaka, Bangladesh
5-Jack Sieber, M.S, David Perky, (2002) “Water Evaluation and Planning System (WEAP) “User Guide, Stockholm, environment institute, SEI-US Water program center, Web: http://www.weap21.org, http://www.sei-us.org.
6- Nadia Shakak, (2018), PhD, Thesis entitle “Planning, And management of water Resources demands and environmental Reforms using advance technology and Modeling, Omdurman University, UNESCO chair in water resource science. Sudan, Khartoum
7-Nadia Shakak, (2015) “Integration of Remote sensing and GIS in ground water quality assessment and management”, The International Archives of the Photogrammetric, Remote Sensing and Spatial Information Sciences, Volume XL-7/W3, 2015 36th International Symposium on Remote Sensing of Environment, 11–15 May 2015, Berlin, Germany1
8-UNESCO - Chair, 2010, “Sudan report” Omdurman University, Khartoum.
9-WHO, (2002)”Guideline 2 for water quality standard” Geneva