Journal of Health and Medical Sciences

Ibrahim, F. M., El Hassan, B. M., Elmanssury, A. E., Siyam, A. M., Dafaallah, S. A., Mughal, Y. H., & Jaber, M. (2024), Integrated, Decentralized Wastewater Management Use to Improve the Environmental Health of Khartoum Locality Sudan. *Journal of Health and Medical Sciences*, 7(2), 97-108.

ISSN 2622-7258

DOI: 10.31014/aior.1994.07.02.321

The online version of this article can be found at:
https://www.asianinstituteofresearch.org/

Published by:
The Asian Institute of Research

The Asian Institute of Research *Journal of Health and Medical Sciences* is a peer-reviewed International Journal. The journal covers scholarly articles in the fields of Medicine and Public Health, including medicine, surgery, ophthalmology, gynecology and obstetrics, psychiatry, anesthesia, pediatrics, orthopedics, microbiology, pathology and laboratory medicine, medical education, research methodology, forensic medicine, medical ethics, community medicine, public health, community health, behavioral health, health policy, health service, health education, health economics, medical ethics, health protection, environmental health, and equity in health. As the journal is Open Access, it ensures high visibility and the increase of citations for all research articles published. The *Journal of Health and Medical Sciences* aims to facilitate scholarly work on recent theoretical and practical aspects of Health and Medical Sciences.

ASIAN INSTITUTE OF RESEARCH
Connecting Scholars Worldwide

The Asian Institute of Research
Journal of Health and Medical Sciences
Vol.7, No.2, 2024: 97-108
ISSN 2622-7258

DOI: 10.31014/aior.1994.07.02.321

Integrated, Decentralized Wastewater Management Use to Improve the Environmental Health of Khartoum Locality Sudan

Faisal Merghani Ibrahim[1], Bashir Mohammed El Hassan[2], Ahmed Elnadif Elmanssury[3], Ahmed Musa Siyam[4], Safa Abdaalla Dafaallah[5], Yasir Hayat Mughal[6], Mahmoud Jaber[3]

[1] UNESCO Chair in Water Resources, Omdurman Islamic University, Khartoum, Sudan
[2] Faculty of Engineering, University of Khartoum, Khartoum, Sudan
[3] Department of Public Health, College of Applied Medical Sciences, Qassim University, Buraydah 51452, P.O. Box 6666, Saudi Arabia
[4] UNESCO Chair in Water Resources, Omdurman Islamic University, Khartoum, Sudan
[5] Department of Public Health, College of Public Health & Health Informatics, University of Hail, Hail, Saudi Arabia
[6] Department of Health Informatics, College of Applied Medical Sciences, Qassim University, Buraydah 51452, P.O. Box 6666, Saudi Arabia

Correspondence: Ahmed Elnadif Elmanssury, Department of public Health, College of Applied Medical Sciences, Qassim University, Buraydah 51452, P.O. Box 6666, Saudi Arabia. Tel: +966502322462.
E-mail: a.elmanssury@qu.edu.sa

Abstract
The management of water resources and the related disposal of wastewater are essential for human existence and the advancement of contemporary society. Collecting and managing wastewater has a significant effect on local and global economies as well as the environment. Innovation in the field of the environment is of utmost importance in reducing the environmental impacts on systems and in making them more sustainable economically, environmentally and socially. Decentralization is considered an appropriate solution to sustainability problems in liquid waste management programs because it focuses on treating liquid waste on-site, recycling it locally, and taking advantage of the local resources available in domestic wastewater. This research analyzes the needs, appropriate technical methods, and support for water management through decentralized systems. Three considerations will be used to support the choice of a decentralized wastewater treatment system in the Khartoum Locality: $106,000,000. According to the BioWin results, the effectiveness of each alternative household wastewater treatment was comparable. Software such as MapInfo, GPS Area Calculator, BioWin, and GIS was used to reach the targets. Additionally, the results revealed that the decentralized wastewater treatment method, considering its costs, land requirements, and slope effects on the environment, is preferable to centralized wastewater treatment systems. These results serve as a guide for choosing the best wastewater treatment option to increase access to safe sanitation and to integrate decentralized wastewater management to upgrade and improve the environment in the Khartoum Locality.

Keywords: Wastewater Management, BioWin, MapInfo, Recycling, Environmental Impacts, Environmental Consequences, Decentralized

1. Introduction

Sustainability is challenged by urban deterioration, especially in fast-expanding places, such as Khartoum, where population density limits access to sanitary facilities (Capodaglio, et al., 2017). To guarantee appropriate management and accessibility, Article 6 of the Sustainable Development Goals mandates the support and modernization of wastewater treatment systems and sanitation services (UNDP, 2017). Urban decay presents sustainability issues, particularly in fast-growing places, such as Khartoum, where access to adequate sanitation is constrained due to a smaller population (UNDP, 2017). Goal 6 of the United Nations Sustainable Development Goals ("Clean Water and Sanitation") It is expected to achieve passable and justifiable access to hygiene and environmental health services in the year 2030, and at the same time reduce the rate of production of untreated liquid waste by half with the increase in recycling services and safe use at a high level globally, as at the present time there are no less than 1.8 billion The world deals with drinking water sources that are contaminated with human waste, while more than 1.7 billion people live in river basins, and more than 80% of the liquid waste resulting from human activity is disposed of without any treatment (WHO, 2019). According to the WHO 2019, 3800 children under the age of five die every day from unhygienic circumstances, inadequate hygiene, and tainted water, with the cost to nations reaching 5% of their GDP, whereas simple sanitation initiatives pay for themselves five times over (Risch, et al., 2015). The gathering and management of liquid waste have a substantial effect on local and global environmental and economic levels (UN, 2022) Owing to limited sanitation and wastewater treatment facilities, Khartoum State faces considerable hurdles in wastewater treatment and environmentally friendly growth (UNEP, 2002). Despite the inhabitants' tolerance for septic tanks, World Bank research demonstrates that septic tank discharge in the Khartoum Locality causes water diseases, flies, mosquitoes, and pollutes shallow aquifers. According to Khartoum Locality's 2018 National Environmental Standard, residential BOD emissions were higher than the national average. Given that 26% and 46% of the world's population lack access to clean water and sanitary facilities, respectively, these necessities are essential for promoting public health (CBS, 2018). Decentralization is becoming more popular in outlying areas as cities relocate to the countryside, feeding 25% of the US population more than ten years ago, while also facilitating future growth (Ministry of Irrigation, 2013) Sudanese officials are hesitant to discharge treated wastewater into the Nile River (Jones, et al, 2012). despite their technical feasibility. There is a scarcity of water resources in North Africa and the Middle Eastern countries. There is an immense need to reuse wastewater after adequate treatment (El Moll, 2023). The collection of wastewater significantly influences the environment both globally and locally. One solution to achieve sustainability is the decentralization of wastewater management (Capdaglio, 2017). Scarce empirical evidence is available on the decentralization of wastewater management in Khartoum, Sudan. Originality and novelty lie in improving the environment and attaining sustainability in terms of economic, environmental, and social terms, as well as environmental health. This is one of the pioneer studies which has contributed towards water management of decentralized system in Sudan. This study aimed to enhance water and human health protection in Khartoum.

2. Method

2.1 Study area

Khartoum locality is located geographically at the confluence of the Blue Nile and the White Nile. It is bordered by the Jebel Aulia locality to the west, Al-Jazeera State to the south, and Blue Nile to the east (Fig.1). Khartoum is relatively flat at an elevation of 385 m. The total area of the locality is 135.33 km2. The population is 834,573 people.

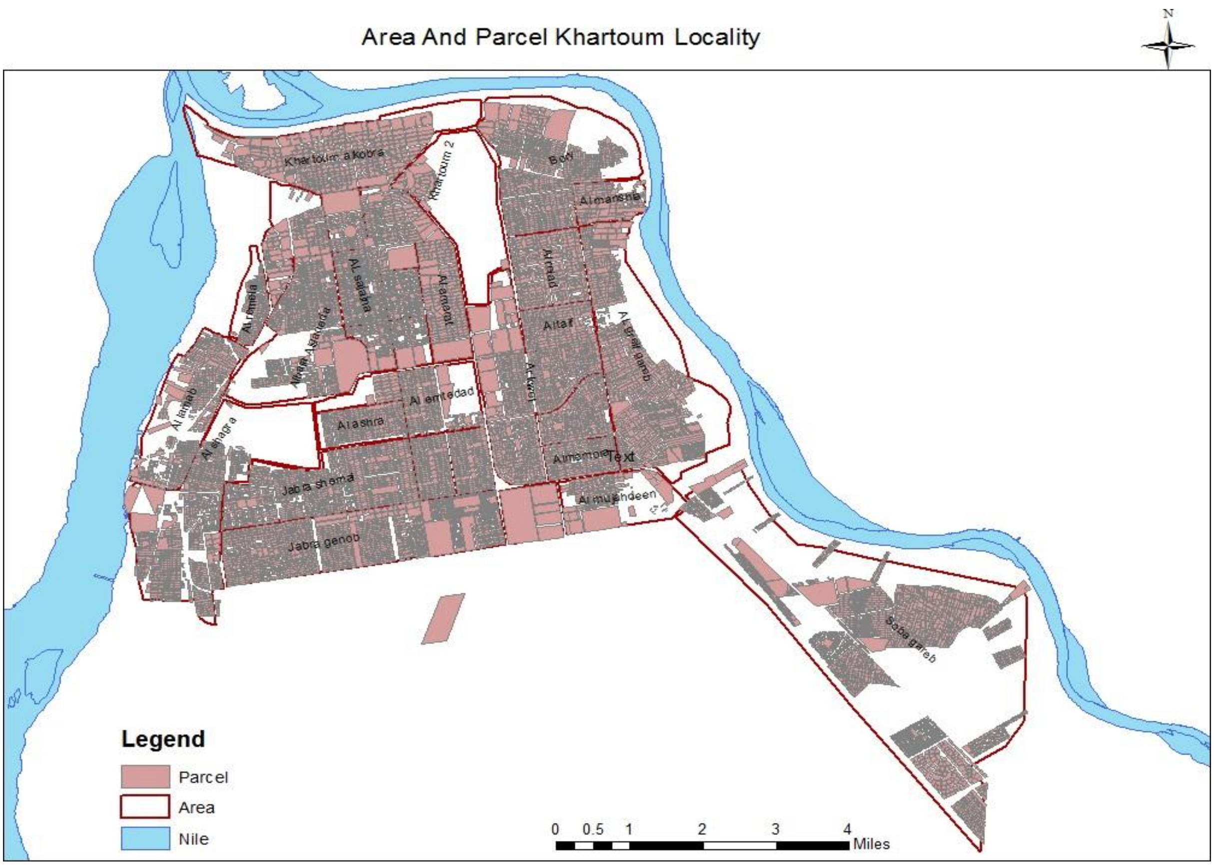

Figure 1: Khartoum Locality Area

2.2 Data collection

This study developed and modeled a wastewater treatment system, highlighting social and environmental challenges, using data from the study area, raw sewage characteristics, and daily wastewater.

2.3 Treatment plants

Several factors, such as environmental, economic, and social criteria, should be considered when evaluating the efficacy of wastewater treatment systems to choose the best system. Using tools such as MapInfo, GPS Area Calculator, BioWin, and GIS, this study analyzed the land requirements, expenses, and wastewater treatment systems of the Hospital Soba University Plant and Arkwet Hospital Al-Galeb Plant.

2.4 Data analysis

The study utilized various tools to evaluate the survey data, focusing on the predicted population, plant types, and wastewater treatment plant design capacity. An analysis flowchart for this investigation is shown in Fig (2)

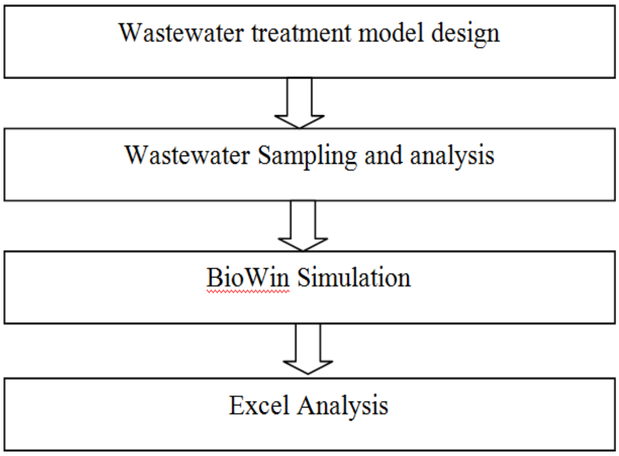

Figure 2: An analytical diagram for the best design of waste water system in Khartoum locality

2.5 Decentralized system

Using the decentralized system for each area independently, the treated water inside each region was drained to irrigate the grass and trees, and the remaining water was drained to the Nile in accordance with the necessary Sudanese requirements. The amount of wastewater that needs to be treated in Table 1in the area of Khartoum. Khartoum Locality Master Plan for Sewage Treatment Facilities and Sewerage Networks Disposal and reuse

2.6 Scenarios

Specific guidelines are adhered to for pipeline routes and WWTP locations, such as avoiding new lifting stations, removing pumping stations, and avoiding opposing slopes. Each area has its own supply owing to a decentralized system that drains treated water for grass and trees and dumps the leftover water into the Nile. To irrigate agricultural areas around Khartoum, 25% cubic meters of water are needed each day or roughly 24666.82 m3/day. Geographical Information System (GIS): The locations of the treatment facilities, pumping stations, and sewer network were chosen using GIS. The positions suggested in Figure 3 depict the locality around Khartoum's proposed initial location for wastewater treatment plants. The well-known computer program.

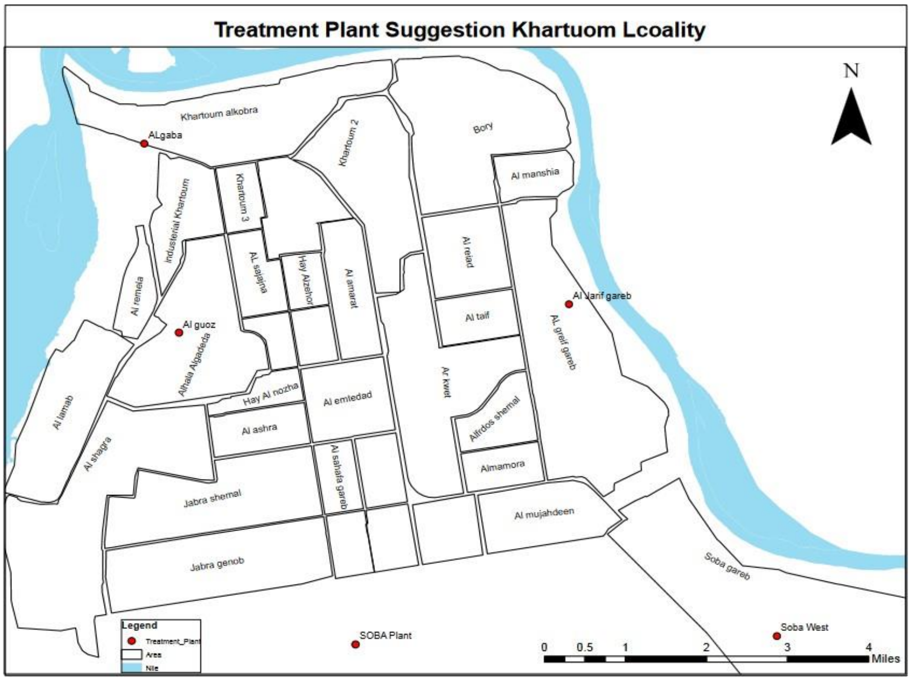

Figure 3: Suggested preliminary location for treatment wastewater plants in the Khartoum locality

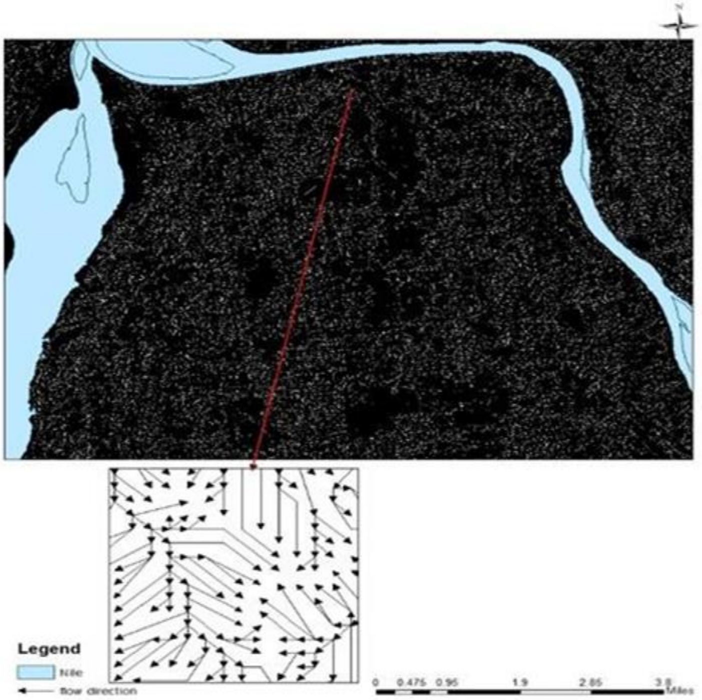

Figure 4: The natural slopes are towards the Nile River

2.7 Bio Win Simulation

Bio Win (version 6.0), created by EnviroSim Associates, is used to simulate the wastewater treatment process. Using physical, biological, and chemical process models, BioWin is used to build, improve, and optimize all types of wastewater treatment plants (Balkema, 2002). This study employed BioWin to generate two liquid waste treatment methods, with every method running independently in the BioWin model. Outcomes were examined to determine if they were effective and if the effluent parameters fulfilled Khartoum's water pollution guidelines. If the effluent concentrations did not reach the limits after five days, the parameters were changed, and the imitation was frequented until the sewage met the criteria.

2.8 Wastewater Estimation

Generally, it is assumed that 80% is ordinary water of the total water contained in the use of ordinary water is discharged as treated water according to ordinary water engineering. (Fane, 2005), and the introductory possibility of explosion of wastewater management in the Khartoum Locality. Consequently, the internal liquid waste movement was considered, as shown in Table (1) as follows: On behalf of defining the size of wastewater treatment plants, approximately five stations were designed in the study. The number of upcoming people in 2048 is estimated to be 1,855,998 people; consequently, in this study, a family size of seven persons was adapted for computing the liquid waste run for all stations. The required number of liquid waste treatment plants and their design capacities depend on population expectations and the types of plants that are designed (Capodaglio, 2016).

Table 1: The quantity of wastewater to be treated and the available empty agricultural lands in Khartoum locality

No	Name of plants	Open irrigated space (acre)	Waste water m^3/day	Design m^3/day	Unit price ($)	Station cost ($)
1	Soba west	682.65	5483.5	10000	1000	10000000
2	AL-Jerif gareb	1033.3	19685.23	20000	800	16000000
3	Soba Plant	-	19685.23	20000	800	16000000
4	Al ghaba (forest)	286.35	35318.304	40000	800	32000000
5	Al Guoz	412.28	38076.88	40000	800	32000000
6	Total	1897.9	118249	130000	-	106000000

2.9 Sustainable Design of New Decentralized Wastewater Treatment systems

The technology that can be implemented in distributed systems includes a wide range of operations that vary in complexity and sophistication. In terms of cost, advanced technologies are quickly becoming comparable to centralized applications (Istenic, et al, 2015). Decentralized facilities are currently easy to control remotely, which helps in the process of operation and maintenance. The deficiency of consistent technologies for inaccessible observation constitutes a thoughtful problem for decentralization, which leads to unsustainable requirements for workers and unreliable treatment (Chong, et al, 2013).

Processes performed in effluent treatment tanks lead to a decrease in the conversion of organic components. Estimates show that approximately half of the organic matter may be transformed into effluent treatment tanks, contingent on the temperature of operation and preservation. Applications of liquid waste treatment systems allow the partial reuse of water, which has some important limitations (WHO, 1992. Ormiston, et al, 2004).

Two types of decentralized systems that are available in developed and developing nations make up wastewater treatment systems under consideration for decentralized systems. Because they are simple to use and maintain, very effective, and the right technology, two in particular, stabilization ponds and MBBR, were chosen and used for the analysis of the system shown in Figures 3, 4, and 5 (among many others). The three wastewater treatment models considered in the Bio Win simulations took into account.

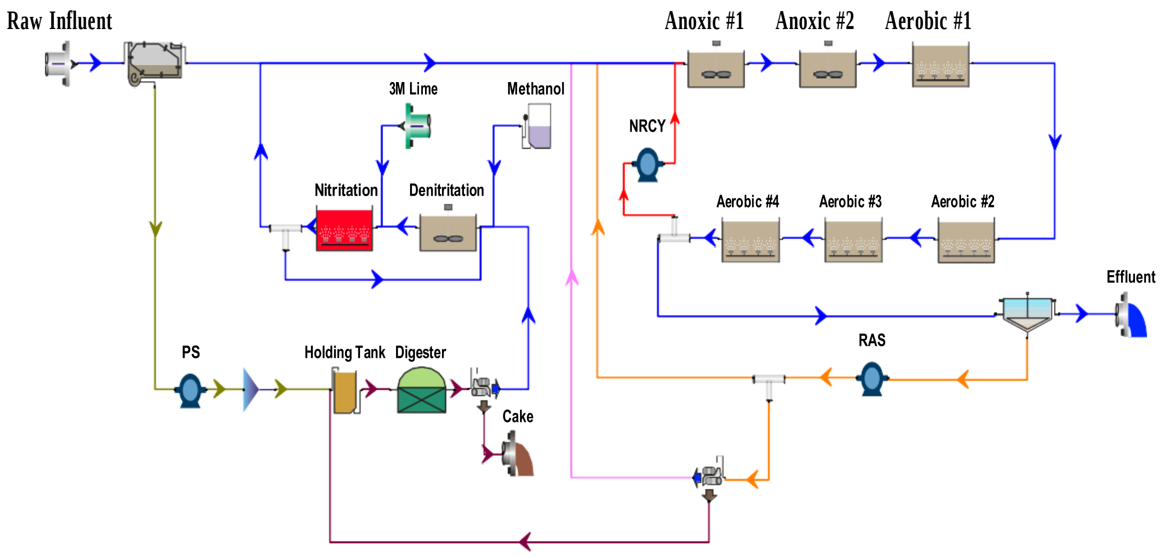

Figure 5: Al-Jarif ghareb treatment plant with design capacity 20.000 m3/day

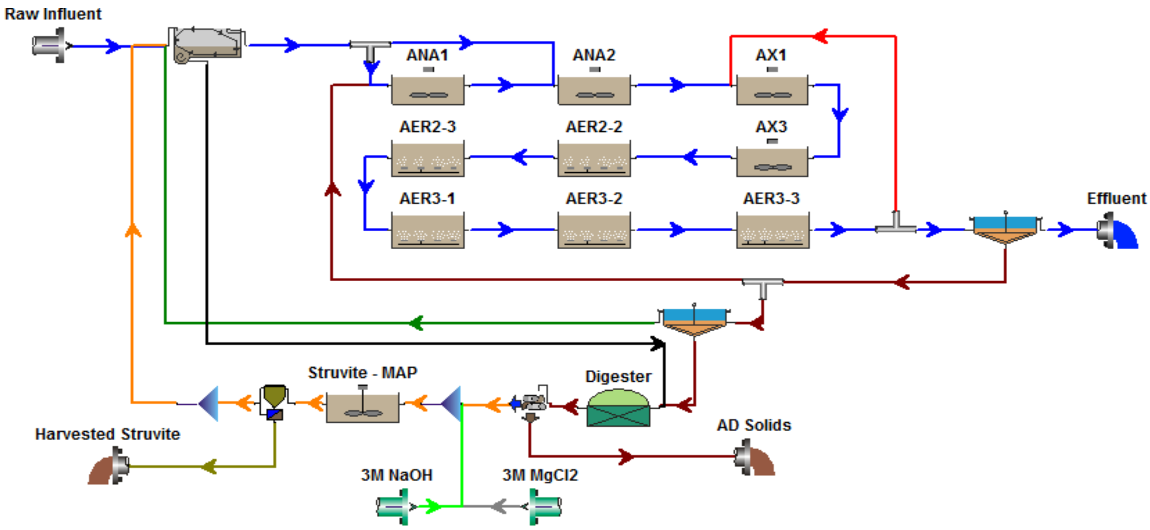

Figure 6: West Soba treatment plant with design capacity 10,000 m3/day

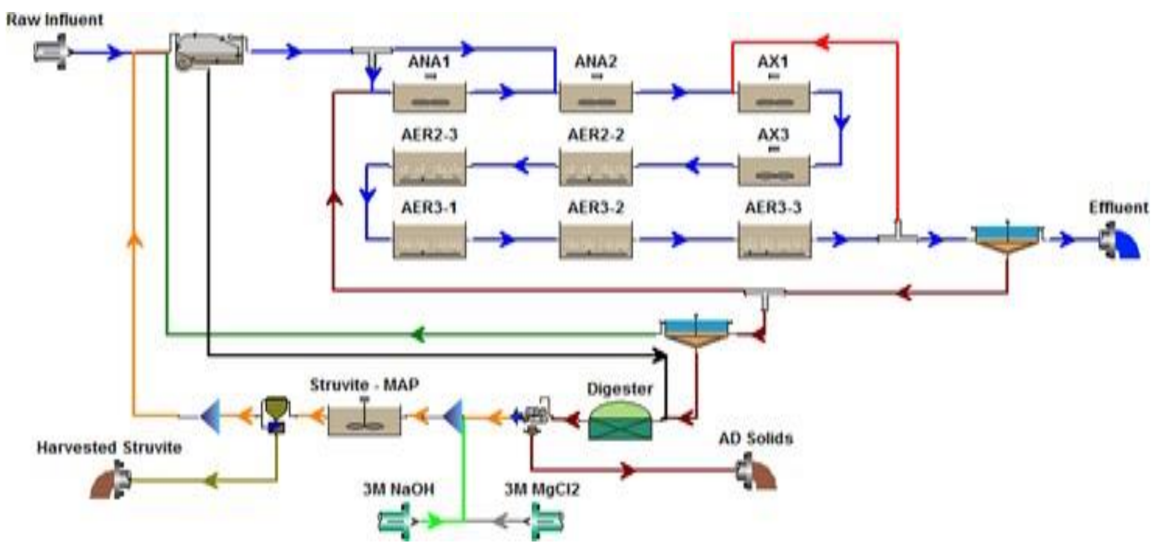

Figure 7: Al-Guoz treatment Plant with design capacity 40000 m3/day

We carefully examined and used the following recommendations when creating the three models: Improvement of On-Site Health Strategies (USEPA, 1980). On-site liquid waste Structures: Project and Administration Guide, on-site liquid waste Management System Manual, Water and Wastewater Calculations Manual are some of the manuals that are available. Engineering wastewater treatment (USEPA, 2014, Andrea, 2017). Engineers working in this field of research are key guides for designing sanitation and wastewater treatment systems.

3. Results

Table 2: Representing the quantity of wastewater to be treated and available for agricultural land and design plant of decentralized treatment plant in Khartoum Locality

S#	Plant	Design Plants M^3/d	Area Acre	Water needs for each area M^3/d	Wastewater M^3/d
1	Al-Jarif West	20000	1033.3	9033.7	19685.23
2	Soba West	10000	1365.3	11796.13	5483.5
3	Al-Qaba	40000	572.6	4910.1	35318.3
4	AlGuze	40000	824.6	7277.8	38076.9
5	Soba pLant	20000	-	-	19685.23
6	Total	130000	3795.7	32958	118249

From Table 2, it can be seen that the al-Jarif West and Soba plants have more wastewater m3/d (19685.23), followed by AlGuze which is 38076.9 m3/d and Soba West (5483.5 m3/d respectively.

3.1 Requirements for the Discharge of effluents into Surface Waters

The Sudanese Standards Organization created a specification for wastewater reuse that is distinct from the international standards. While the laws are the same in Europe and the US, they differ in other countries, such as India. While the European and American regulations are 15 mg/L, Western countries recommend a BOD5 value of 25 mg/L for water before it is dumped into rivers. The Nile River's capacity and flow rates are incomparable to those of the Rhine or Thames.

Table 3: Daily Discharges of the Nile Rivers and River Thames

River Gauging Location	Daily Minimum Flow on Record in million m^3	Daily Average Flow in million m^3	Daily Maximum Flowin million m^3
River Nile (Gauge located Further downstream of Khartoum)	40 M m^3 or 463 m^3/sec	185 M m^3or 2141 m^3/sec	910Mm^3or10532m^3/sec
Blue Nile (Gauge located at Khartoum)	0.25Mm^3 or2.89m^3/sec	119Mm^3or1377m^3/sec	955Mm^3or11053m^3/sec
White Nile (Gauge located at Khartoum)	55 Mm^3 or 637 m^3/sec	75 Mm^3 or 868 m^3/sec	175Mm^3or 2025 m^3/sec
River Thames (Gauge located at Teddington)	0.846Mm^3 or 10 m^3/sec	6.74Mm^3 or 78 m^3/sec (London:65.8 m3/s)	91.50Mm^3or1059m^3/sec

3.2 Bio Win Simulation

The concentrations of BOD, COD, and TSS in the two wastewaters after the BioWin simulations are shown in Table (3). Simulations were run for five days to determine whether the wastewater treatment models matched the water pollution control guidelines set by the Khartoum Locality. The adjustable parameters were changed, and the process was repeated until the standards were met.

Table 4: Results of studies conducted at two plants for wastewater treatment

Test	**Unite**	**Soba Hospital University Plant**		**BioWin**	**Arkwet Hospital Al-galeb Plan**		**BioWin**
		In let	**Out let**	**Out let**	**in let**	**Out let**	**Out let**
BOD	Mg/L	566.6	360	6.64	250	90	6.64
COD	Mg/L	600	440	53.39	560	256	53.39
TSS	Mg/L	4550	700	19.51	220	20	19.51

Laboratory evaluation confirmed that stations operate beyond the environmental restrictions of Khartoum Governorate's water resource protection system, and wastewater quality exceeds permissible limits. De Graaff et al. reported that decreases in total Chemical Oxygen Demand (COD) up to 80–90% were described, and straight at lower temperatures (above 20 _C), average exclusions of approximately 70% could be expected.

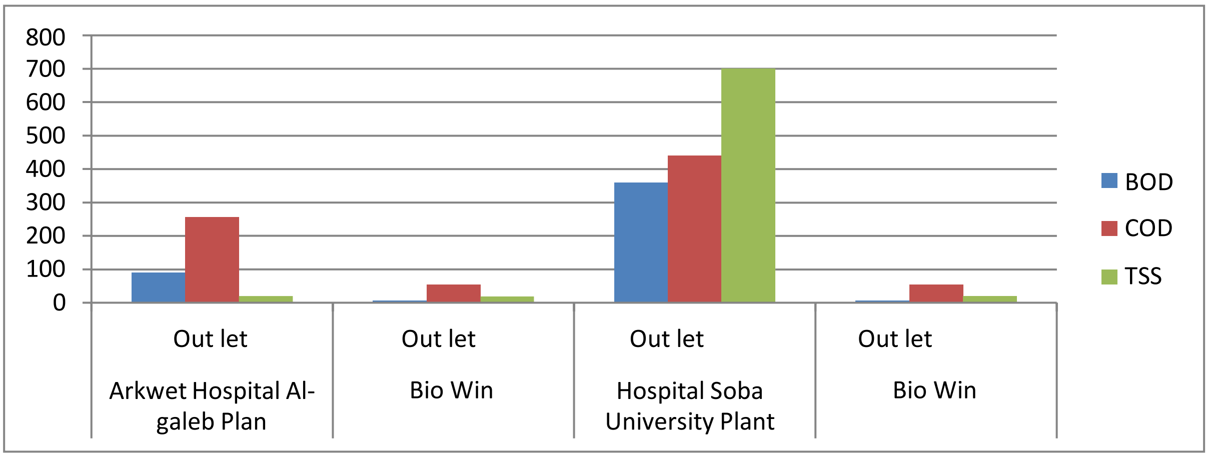

Figure 8: Comparison of plant efficiencies before and after designing BioWin

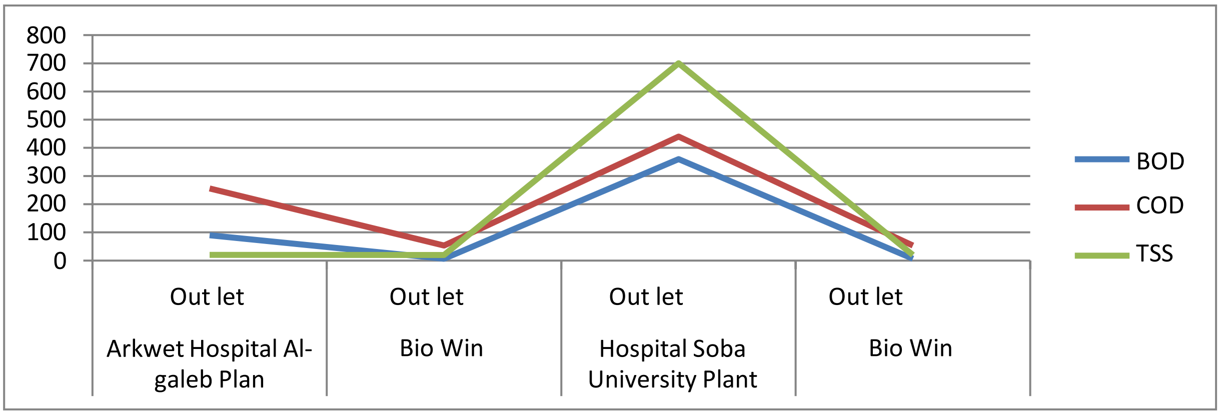

Figure 9: The results of the laboratory examination, which revealed that all stations operate beyond the environmental limitations of the system permitted to protect the water resources of the Khartoum Locality and that the quality of wastewater exceeds the authorized environmental limits.

4. Discussion

Our study shows replicated sewage BOD, COD, and TSS concentrations in the two wastewater treatment models. The three wastewater flow parameter limitations for controlling domestic wastewater release were BOD: 15 mg/L, COD: 75 mg/L, and TSS: 30 mg/L. Therefore, none of the focuses met the Khartoum local water pollution standards for domestic wastewater and Khartoum local control standards for domestic wastewater. In terms of the flatness of the land, it tends to the north, that is, at the level of the Nile, and this reduces the cost of construction at the level of the sewage network, land requirements, there are open spaces and public areas within the Khartoum locality, which must be irrigated with treated wastewater. Although the methods now adapted for individual services have contributed to significant development in public health, sustainable solutions remain a requirement in light of the increasing need for resources due to the increase in population (Ma, et al,2017. US EPA 1997).

Liquid waste is classified into four types of services according to the primitive classification of water management, each of which is managed according to specific rules and depends on the others. By assessing complex water issues in an integrated manner, any comprehensive water system can be sustainable and balanced with local economic and environmental services (Massoud, et at. 2009). The importance of central water systems lies in unification, which allows them to meet the needs of water and quality standards on a large scale. They are also subject to a certain degree of financial, organizational, and technical stagnation. Studies on acute water shortages and related factors have focused on water reuse.

It is difficult to benefit from treated water in the case of a central sewage treatment system due to the increased operational cost, because the central treatment plants are outside the region, while it is possible to benefit from it in the case of a decentralized system. Discharging treated water in excess of the region’s needs into the Nile River and its tributaries. But in terms of cost, the decentralized system appears less expensive, so it is easier to implement, while the centralized system shows high cost. There are great benefits the decentralized infrastructure can provide by spreading the risks of drought and miasma between deferent locations.

The US Environmental Protection Agency (EPA) has recognized that “decentralized wastewater systems may provide a cost-effective and long-term option for meeting public health and water quality goals, particularly in less densely populated areas” (Tchobanoglous, et al, 2003). According to the questionnaire (trying to find solutions to the sewage problem in Khartoum State), 79.4 % of the population rejects the establishment of a sewage station in the neighborhoods, while 20.6 % agree. To establish a sewage plant in the neighborhood. Therefore, the government must intervene and solve the problem in accordance with the higher interests of the region. The sultan in Khartoum wants open spaces and streets to be green, but this cannot be achieved unless the system is decentralized. The decentralization option relates to several matters considered important, such as planning and decision-making, for example. In practical terms, it can enhance the role of citizens and be a means of resolving local environmental and health concerns accurately, and it may also help improve services (Burton, et al, 2013). The decentralized system often tends to meet the needs of local water use, as treated water helps increase agricultural productivity and is also suitable as an alternative to landscaping and replenishing groundwater resources (Environs Associates, 2018).

There are advantages of systems. On the other hand, there are disadvantages as well. In a centralized water system there is uniformity, and it assures the demand and quality standard of the population. Due to shortages of water resources and other related factors, communities insisted on paying adequate attention to using water. In addition, decentralized water system can spread a high risk of drought in the locality. In a decentralized water system, local water reuse could be used to increase agricultural productivity. Decentralization is a holistic method. It helps the locality to reduce waste of water, helps recycling, and also helps to keep the wastewater collection component at the minimum level. Decentralization method help to reduce the cost by 60% as com-pared to centralized method of water management, thus helping in obtaining sustain-ability and improving environmental health.

5. Conclusion

This study evaluated a wastewater decentralized treatment system in Khartoum Locality, focusing on stabilization ponds and MPR technologies. The decentralized stations were found most suitable for urban liquid waste management. The study used wastewater engineering calculations, BioWin simulations, and Excel analysis to evaluate sanitation and wastewater treatment development. The study highlights the importance of considering other factors like sludge management, transportation, effluent discharge, and economic costs for installation, operation, and maintenance. The study emphasizes the need for expert and government opinions in wastewater treatment selection.

The current study has discussed in detail the decentralization method of water management, its benefits and disadvantages. Decentralization method help to improve environmental health, agricultural productivity, reduce cost and help in obtaining sustainability. Due to drought risk, the decentralization method of water management is attracting the attention of researchers and practitioners. Reuse of water not only reduces the cost but also decreases the demand for chemical fertilizers for the agricultural sector. Treated water also helps in the reduction of water crises such as wastewater pollution and lack of water in Khartoum locality, Sudan. Decentralization method would improve water management system and reuse of water help to preserve the natural environment and economic development of the country.

Author Contributions: Conceptualization, Faisal Merghani Ibrahim, Bashir Mohammed El Hassan.; methodology, Faisal Merghani Ibrahim.; software, Ahmed Musa Siyam.; validation, Safa Abdaalla Dafaallah; formal analysis, Faisal Merghani Ibrahim; investigation Bashir Mohammed El Hassan, Resources, Faisal Merghani Ibrahim.; Data Curation writing—original draft preparation, Ahmed Elnadif Elmanssury.; writing—review and editing, Yasir Hayat Mughal.; supervision, Bashir Mohammed El Hassan. All authors have read and agreed to the published version of the manuscript.

Funding: Not applicable

Conflicts of Interest: The authors declare no conflict of interest.

Informed Consent Statement/Ethics approval: Not applicable.

Acknowledgments: The author thanks the University of Khartoum, Department of Chemical Engineering, Khartoum State Sanitation Authority and all volunteers for providing instrument.

References

Capodaglio, A.G.; Callegari, A.; Cecconet, D.; Molognoni, D. (2017). Sustainability of decentralized wastewater treatment technologies. Water Pract. Technol., 12.

UNDP Millennium Development GoalsWebsite (2017). Available online: http://www.undp.org/content/undp/en/home/sustainable-development-goals.html (accessed on 16 March 2017).

UNDP Millennium Development GoalsWebsite (2017). Available online: http://www.undp.org/content/undp/en/home/sustainable-development-goals.html (accessed on 16 March 2017).

Water, sanitation, hygiene and health: a primer for health professionals. Geneva: (2019),World Health Organization; (WHO/CED/PHE/WSH/19.149). Licence: CC BY-NC-SA 3.0 IGO.

Risch, E.; Gutierrez, O.; Roux, P.; Boutin, C.; Corominas, L. (2015).Life cycle assessment of urban wastewater systems: Quantifying the relative contribution of sewer systems. Water Res., 77, 35–48. [CrossRef] [PubMed]

UN. The 17 Goals. (2022). Department of Economic and Social Affairs. Sustainable Development.. Available online: https://sdgs.un.org/goals (accessed on 18 July 2022).

UNEP. (2002). Environmentally Sound Technologies for Wastewater and Storm water Management: An International Source Book; IWA Publishing, The United Nations Environment Programme, International Environmental Technology Centre: London, UK; Osaka, Japan,.
Central Bureau of Statistics (CBS) Statistics, (2018). Republic of Sudan.
Ministry of Irrigation, Khartoum, Sudan, 2013. River Nile Discharges Records taken in 2013.
Jones,E. 1983. “Flow Gauging on the River Thames – the First 100 Years” Hydrological Data1983 www.ceh.ac.uk/.../Flow_Gauging_on_River_Thames_100_Years.pdf
El Moll A .(2023). Eco-innovative technology for wastewater treatment and reuse in MENA region: case of Lebanon. Front. Sustain. 4:1247009. doi: 10.3389/frsus1247009
Capdaglio AG, (2017) Integrated, Decentralized Wastewater Management for Resource Recovery in Rural and Peri-Urban Areas, Resources, 6, 22; doi:10.3390/resources6020022
Balkema, A.J.; Preisig, H.A.; Otterpohl, R.; Lambert, F.J.D. (2002). Indicators for the sustainability assessment of wastewater treatment systems. Urban Water, 4, 153–161. [Google Scholar] [CrossRef].
Fane, A.G.; Fane, S.A. The role of membrane technology in sustainable centralised wastewater systems. Water Sci. Technol. 2005, 51, 317–325. [PubMed]
Capodaglio, A.G.; Callegari, A.; Molognoni, D. (2016). Online monitoring of priority and dangerous pollutants in natural and urban waters: A state-of-the-art review. Manag. Environ. Qual., 27, 507–536. [CrossRef]
Istenic, D.; Bodík, I.; Bulc, T. (2015). Status of decentralised wastewater treatment systems and barriers for implementation of nature-based systems in central and eastern Europe. Environ. Sci. Pollut. Res. Int., 22, 12879–12884. [CrossRef] [PubMed]
Chong, M.N.; Ho, A.N.M.; Gardner, T.; Sharma, A.K.; Hood, B. (2013). Assessing decentralised wastewater treatment technologies: Correlating technology selection to system robustness, energy consumption and GHG emission. J. Water Clim. Chang, 4, 338–347. [CrossRef]
WHO. (1992). A Guide to the Development of On-Site Sanitation; WHO: Geneva, Switzerland; p. 229. [Google Scholar].
Ormiston, A.W.; Floyd, R.E. (2004). On-Site Wastewater Systems: Design and Management Manual; Auckland Regional Council: Auckland, New Zealand, Volume 58.
USEPA. Design Manual (1980). Onsite Wastewater Treatment and Disposal Systems; US Environmental Protection Agency: Washington, DC, USA. p. 409
USEPA (US Environmental Protection Agency) (2014). Onsite Wastewater Treatment System Manual; US Environmental Protection Agency: Washington, DC, USA, 2002; p. 367
Lin, S.D. (2020). Water and Wastewater Calculations Manual, 3rd ed.; McGraw-Hill Education: New York, NY, USA,. [Google Scholar]
Andrea G. (2017). Capodaglio, Integrated, DecentralizedWastewater Management for Resource Recovery in Rural and Peri-Urban Areas, Resources, 6, 22; doi:10.3390/resources6020022.
United Nations Environment Programme (UNEP). (2012). Status Report on the Application of Integrated Approaches to Water Resources Management; United Nations Environment Programme: Nairobi, Kenya; p. 119.
Ma, X.C.; Xue, X.; González-Mejía, A.; Garland, J.; Cashdollar, J. (2015). Sustainable water systems for the city of tomorrow—A conceptual framework. Sustainability, 7, 12071–12105. [CrossRef]
United States Environmental Protection Agency (US EPA). (1997). Response to Congress on Use of Decentralized Wastewater Treatment Systems; EPA-832-R-97-001b; US EPA Office ofWater: Washington, DC, USA.
Massoud, M.A.; Tarhini, A.; Nasr, J.A. (2009). Decentralized approaches to wastewater treatment and management: Applicability in developing countries. J. Environ. Manag, 90, 652–659. [CrossRef] [PubMed]
Tchobanoglous, G.; Burton, F.L.; Stensel, H.D.; Metcalf Eddy, Inc.; (2003). Burton, F. Wastewater Engineering: Treatment and Reuse; McGraw-Hill Education: New York, NY, USA. [Google Scholar].
Burton, F.L.; Tchobanoglous, G.; Tsuchihashi, R.; Stensel, H.D.; Metcalf Eddy, (2013). Inc. Wastewater Engineering: Treatment and Resource Recovery; McGraw-Hill Education: New York, NY, USA. [Google Scholar].
Environs Associates. Process Model Formulation, (2017). Available online: https://envirosim.com/products/biowin (accessed on 28 January 2018).