

Effective quality control of a municipal wastewater treatment plant using Geographic information systems: A Review

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ABSTRACT

Inefficient wastewater disposal and wastewater discharge problems in water bodies have led to increasing pollution in water bodies. Pollutants in the river contribute to increasing the biological oxygen demand (BOD), total suspended solids (SS), total dissolved solids (TDS), chemical oxygen demand (COD), and toxic metals render this water unsuitable for consumption and even pose a significant risk to human health. Over the last few years, water conservation has been the subject of growing awareness and concern throughout the world, so this research focused on review studies of researches that studied the importance of water quality of wastewater treated disposal in water bodies and modern technology to management wastewater disposals.

Keywords: municipal wastewater treatment plant, management disposal, efficiency control, wastewater, GIS.

مراقبة فعالة لنوعية محطة معالجة مياه الصرف الصحي البلدية باستخدام نظم المعلومات الجغرافية: مراجعة

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الخلاصة

أدت مشاكل التخلص من مياه الفضلات غير الفعالة وتصريف مياه الصرف في المسطحات المائية إلى زيادة التلوث في المسطحات المائية. وتسهم الملوثات في النهر في زيادة الطلب على الأكسجين البيولوجي، ومجموع المواد الصلبة الذائبة، والطلب على الأكسجين الكيميائي، ومجموع المواد الصلبة الذائبة، والمعادن السامة تجعل هذه المياه غير صالحة للاستهلاك، بل وتشكل خطراً كبيراً على صحة الإنسان. على مدى السنوات القليلة الماضية، كان الحفاظ على المياه موضوع الوعي المتزايد والقلق في جميع

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أنحاء العالم لذلك ركز هذا البحث على عمل دراسة لمراجعة البحوث التي تدرس أهمية جودة المياه المعالجة للتخلص في المسطحات المائية والتكنولوجيا الحديثة لإدارة التخلص من المياه المستعملة.
الكلمات الرئيسية: محطات معالجة مياه الصرف البلدية، إدارة المطرورات، ومراقبة الكفاءة، مياه الصرف الصحي ، نظم المعلومات الجغرافي

1. INTRODUCTION

As time passes by, there will be an increase in the population day by day that leads to an increase in the requirements of the wastewater treatment plants (**Bhoye, et al., 2016**). As a result of available water with 97% as salty water, 3% freshwater, and just 1% are suitable for human consumption that makes wastewater treatment plant is Essential process of the modern industrial world (**Khan and Salman, 2016**).

Also, the rivers constitute one of the basic resources of surface water and have considerable ecological and economic value. Hydro-chemical composition and water quality have always been influenced by natural (geological) and non-natural (polluting) factors. In particular, in developing countries, continuous monitoring for river systems is essential to assess the impact of factors environment on quality of water for appropriate use and sustainable development (**Kumar, et al., 2015**). In several nations, river water quality is a big concern in terms of agricultural and drinking use (**Mustafa, 2015**). River water is used in Iraq for numerous uses (domestic, agricultural and industrial); For the effective management of water quality, continuous control of a wide range of quality parameters is important. However, the regular monitoring of all parameters is a complex and challenging activity (**Almoula, et al., 2021**). Many researchers work in these cases found that the hazardous impacts of disposal of untreated sewage on water bodies. The treatment of wastewater and appropriate effluent disposal for these products are essential for a safe environment. Economical and efficient wastewater treatment has a significant impact on water conservation, and preventing unnecessary water loss is the best fit and long term to solve the water shortage issue (**Aghalari, et al., 2020**). Wastes must meet specific criteria presented in regulations and criteria if they are to be deemed environmentally acceptable. Chemical and biological analyses of both liquid and whole sludge were used to determine whether there would be significant adverse environmental effects, as specified in the regulations. Chemical analyses of liquid and whole sludge determined the chemical constituents and their potential toxic impact on the environment (**Fava et al., 1985**). The analysis of the physicochemical and microbiological parameters of water is essential to assess the quality of water for the best use, such as irrigation, drinking, swimming, fishing, industrial treatment, and so on. Water quality takes into account physical, chemical, and biological characteristics relative to all other hydrologic properties. (**Kumar, et al., 2015**)

On the other hand, many researchers focused on using modern technology to manage water resources, and one of this technology is geographic information systems (GIS). It is a very useful tool to develop solutions to water resource issues to assess water quality, determine water availability and understand the natural environment locally and/or regionally. The GIS makes it possible to map the spatial distribution of different pollutants. The resulting data is very useful for decision-makers to consider remedial steps (**Alanbari, et al., 2015**). Therefore, the Create thematic maps using geographic information systems (GIS) had been very useful in the design process and analysis. It is enhanced the analysis of sewerage network capacity with respect to the query, display, and mapping results. Using the program (SWMM) in the analysis helped to find out the appropriate pipe diameters of the study area as well as flow velocity and the relationship between time and the amount of water through the illustrative charts for each pipe, joints, and every part of the network with each other (**Hadi, et al., 2015**). Besides, The use of remote sensing and GIS in an integrated way is an essential area of research where the maximum use of this area was made in the analysis and representation of data (**Ameta, 2015**).

2. Wastewater treatment plant

Wastewater may be identifying as all used disposal water, which can be released from homes, restaurants, industries, agricultural plants, etc. Sewage contains substances as human waste, waste



of food, oils and grease, cleaning products, and chemical materials. In general, wastewater is discharged through a large underground network pipes to the wastewater treatment plant where various stages treat polluted water to remove polluting wastewater (**Shahot and Ekhmaj, 2012**). Treating wastewater effluents before they are released to aquatic organisms is vital to preventing pollution and protecting the environment and public health in general. (**AK, 2017**).

Many scientists have studied the process of sewage treatment and have reached the basic fact of treatment, which is the process of decomposition of complex compounds to simpler materials without negatively harming the environment. This treatment is carried out by a number of stages of treatment, whether this treatment is physical, chemical, or biological. If the wastewater is released without these treatments, it decreases the proportion of dissolved oxygen, increased nutritional loads, and accumulates toxic substances. (**Akpor and Muchie, 2011**).

Also, increasing food loads leads to the growth of many algae and aquatic plants that reduce the oxygen content in water in addition to containing Gut bacterium and other types that cause contamination of water bodies, so proper disposal of sewage water is not only desirable. Still, it is essential and needs to establish treatment plants to meet these requirements. (**Topare, et al., 2011**).

The technique KSOFM, a form of the unsupervised neural network, has been an effective tool in finding relationships between complex variables to find efficiency of activated sludge plant and has been an efficient and accurate tool used in other types of treatment plants. (**Hong, et al., 2003**). Anaerobic biodegradability (methane conversion) is an essential metric for evaluating the anaerobic treatment potential of all wastewater (**Elmitwalli, et al., 2003**). Sewage treatment is divided into three kinds of treatment; the First stage is primary treatment; it mainly included removing solid matters by sedimentation and floatation second stage is secondary treatment: This treatment is concerned with biological treatments. That is what happened with various biological processes in which microorganisms break down sludge and water is clear. Activated sludge, aerated lagoon, trickling filters and membrane separation, and third stage Tertiary treatments; biologically treated water undergoes tertiary physiological processes in specially designed sludge covers. The method is principally based on chlorination, disinfection, and pickling of ammonia, etc. (**Joshi and Thakkar, 2019**)

The management of water resources has been the subject of growing awareness and concern worldwide that make research-focused. Establishing monitoring networks in Maine rivers has resulted in a large database covering the variations of pollutants temporal and spatial. On the other hand, almost all countries of the Mediterranean (involve Greece) have weaknesses in the monitoring system of surface water quality. Though of many problems of pollution, the management conservation of riverine systems requires evaluation of the environmental problems of river basin scale with the objective of availability of a more suitable scientific framework for managing the influence activities of humans. To get the approach of best assessment, data are needed that obtained by different geology systems also different human impacts and foundation availability for distinguish between normal level and polluted because there is difference of concentration of the pollutants, the waste released into the river (**Dassenakis, et al., 1998**). It was found that these pollutants present in the river reduce the effects of solar energy absorption, resulting in a lower rate of photosynthesis and slows down natural water purification processes, and the long effect of this is environmental degradation (**Lekwot, et al., 2012**). In the management in choosing positions during the construction of any treatment plant, many problems occur, such as inadequate funds and land, delays in importing equipment and qualified personnel for the operation and maintenance of the plant. Many STPs have not treated wastewater within its allowable limits. It is necessary to choose such a technology that will solve the issues that arise during construction. Another consideration when selecting technology is similar to the treated



water's physical, chemical and biological characteristics. Physical characteristics consist of total solids, color, turbidity, taste and odor, temperature, chemical characteristics, pH, alkalinity, dissolved oxygen, biochemistry oxygen demand, chemical oxygen demand, and chloride. Many organizations, industries, and municipalities did not implement the LCC due to the absence of formal guidelines and difficulty estimating future costs and revenues (**Bhoye, et al., 2016**).

2. Using Geographic information system in wastewater management

Waste management has got profound concern in many countries, where options of management demand characterization widely. Many of them may contain harmful compounds that can impact the ecosystem, such as heavy metals, organic micropollutants, etc. (**Mantis, et al., 2005**). The GIS has also been shown to be an effective tool in finding the appropriate treatment plant location and relying on environmental, economic, and other factors. AHP (Analytical hierarchy process) has been used as a decision-making assistant choosing the best location. (**Aydi, et al., 2019**). GIS is a computer-based software that allows spatial database information to be gathered, processed, analyzed, transmitted, and released. It is especially significant for the presentation of spatial and baseline values. Effects of spatial analysis GIS diagrams from this software have contributed to the investigation of natural and human processes and to their behavioural simulation and estimation over time. Since then, many types of research have been underway in supporting researchers in emerging technologies in all communities instead of using GIS. The use of GIS's evolving potential in the last three or four decades has also increased considerably (**Al-Waeli, et al., 2021**). The importance of the GIS is that it is a tool through which data is collected, managed and analyzed as it provides the possibility of integrating large sets of data from different sources and specifications and most of this data modeling and mapping and in the decision-making tool in the selection of the right place and complete these by several layers may be points, lines or polygons (**Jha and Tukkaraja 2020**).

One of the objectives of integrating remote sensing and geographic information systems is to monitor changes during different periods to understand the relationships between variables and water resource management (**Ameta, 2015**). It also uses GIS in drilling and landfill volume calculations, mining, environmental changes, navigation, and climate change monitoring and provides the possibility of different import files such as Auto-cad and Excel (**Jha and Tukkaraja, 2020**).

Arc GIS Geo-processing is a major component of ArcGIS and includes numerous processes that can be used to extract information from the data presented. The study mentioned the importance of modern technologies to solve the environmental problems of the wastewater treatment plant (WWTP) in the advancement of environmental protection. The study methodology combined remote sensing and GIS techniques to facilitate the study and provide helpful information about the study space. Furthermore, it provides additional correct results over the standard means. As a result, GIS has proven to be a robust tool for special, non-space information management in relevance analysis (**Abbasl and Jassima, 2019**).

The spatially referenced and updated information system is the most important tool for planning, managing, and protecting the wastewater environment. It is necessary to have a system that can provide facilities through Geospatial relationships. Locating wastewater treatment systems are needful components, and this requires spatially oriented data collecting, analyzing, and visualizing. The decision-making capability offered by GIS is well suited for treatment plants as it improves analysis and understanding of existing problems for sewage treatment plants in order to select the most suitable location and to work a comprehensive model based on GIS to



identify social, environmental, and economic factors to find an effective and more comprehensive way to choose the appropriate location for the plant. (M.A., and Ebraheem, 2012).

Remote sensing and GIS have been used as a single unit in water management in identifying the right water sources, watersheds, flood management, and mapping of them, in addition to analyzing surface water and determining the depth of groundwater (Ameta, 2015).

Another research that studied the selection of the appropriate location for the sewage treatment plant was in Sulaimaniyah, Iraq, where the sample was 134 areas and used GIS and AHP (Analytical hierarchy process) in the selection of the appropriate location with the status of a weight ratio to choose the appropriate location which is close to the sites of the main sewage pipes, the area of land available, population density and other factors. (Hama, et al., 2018). GIS was also used in the selection of the pond system in Thrace (Northeast Greece) that was used in the treatment of sewage and took into account the characteristics of the liquid waste, the slope of the land, and the distance between it and the main rivers. (Meinzinger, 2003)

Also, a research paper investigation uses remote sensing and Geographic information system to evaluate problems hydrologists related to wastewater in two main sites (Al Ballanah and Al Allaqi in Aswan, Egypt). It found out remote sensing and Geographic information system ability of use in Monitoring accumulation of wastewater surplus, build a model of hydrological a water balanced which used to manage these sites and specify substitute location in suitable site to storage water and agriculture so the adverse effects of wastewater on the environment can be decreased (El Bastawesy et al., 2017). Moreover, assessment mill waste Water and to achieve this have required investigation Water pollution caused by the effluent of Olive mill. It had been studied the factors of controlling related with it in scales temporal and spatial that the risk generating process needful to modeling and simulating. Furthermore, it has been drawn a complete picture of pollution source's potential, and receptors expected also connecting pathways, making a conceptual model for these environmental problems that the risk generic conceptual and model generating process. Have been defined, the quantitative approach of risk assessment has been built. The perform methodology has demonstrated how applicability and its potentially a tool of supporting the decision (Elhag, et al., 2017). In choosing the best location, certain key criteria must be included; standards of environment, respect of socialite, costs, and other details. Furthermore, the availability of land is one of the requirements that influence on siting of treatment plants. Foremost, it's needed to perform thorough studies also gathering data to choose a suitable location (EPA, 1980).

CONCLUSIONS

To control the effective quality of municipal wastewater treatment plants in technical methods that are done by geographical information systems. The major results achieved from this research can be explained below:

1. The effectiveness of the WWTP in terms of design, implementation, and operation depends on its physical properties, chemical and biological treatments for treated wastewater, and their applicability to global environmental protection specifications.
2. Conduct characteristic tests inside WWTP to control the properties of effluent disposals that possible to recognize the problems that happen in the components of the treatment works.



3. The possibility of using GIS based on remote sensing to perform the effluent quality control of a municipal wastewater treatment plant.

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