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Wastewater Management as a Part of Solution for Water Resources Problem in Erbil City

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ABSTRACT

In Erbil City, municipal wastewater (MWW) is disposed directly without any treatment processes in the natural environment water body and in some places used for irrigation purposes. Untreated MWW causes problems for the environment, and people's health. Water quantity and quality variation produce complications for water sources in Erbil City, Kurdistan Region-Iraq. There is a lack of performing MWW management fundamentals in the area as well. This research aimed to study the MWW management in Erbil City, presenting water resource difficulties and bringing about suitable solutions for the water resource problems, and also to highlight the risk for the poor Management. MWW Data on Erbil municipal (EMWW) water quality parameters were collected and analyzed for the study period (four months), beginning in October 2022 and ending in March 2023. Twelve EMWW quality parameters were captured and tested in the Laboratory, arranged, and compared with MWW disposal criteria and local standards. The following MWW parameters include pH, electrical conductivity (EC), total dissolved salts (TDS), chloride (CL), total solids (TS), total alkalinity, total acidity, chemical oxygen demand (COD), and colour. The results showed that Erbil's MWW characteristics in terms of temperatures ranged between 11-23 °C and in turn, affected biological species activities. Maximum PH value was 7.7. Total alkalinity found in the range from 140 to 178 mg/l. Chloride concentration results showed for October was 62 mg/l and the maximum value was 80 mg/l in November due to the increment in temperature and evaporation. The range of the COD values of sewage water for five months was 246 -773 mg. Erbil's MWW's moderate to medium strength may be treated and utilized for landscaping, fountains, and irrigation, minimizing the need for fresh water from resources like wells and surface water in the Greater Zab River.

1.Introduction

The contaminant concentrations in the WSW frequently exceeds the allowable standard limits for direct disposal in to the body of water (Al-Zboon, 2012), therefore the legislations prevents direct disposal and suitable treatment process should be carried out (Bapeer, 2010; Aziz, 2020). There is increment in the volume of the MWW due to the migration peoples in rural to the urban areas as a result of urbanization, also the movement of people (displacement and Refuges). This increment required a fast action to find solution for safe final discharge for the huge amount of WSW, which reaches around (200,000 m^3/d) and required to use treatment different which needs a proper sewerage system includes collection, transmission and treatment components. In Erbil city, 75-80% of daily consumed water for various usages in domestic and industrial section turns to WSW (Aziz, 2020) and till now it is discharged directly to the final water body (Great –Zap river) without any treatment and as mentioned will produce risk to the people health settled down in the downstream. A sewerage line system is constructed in Erbil city which covers only 45% of the total area for collection of storm water drain and domestic includes institutions, commercial, Schools, Hotels, hospitals and other comparable services then discharged without treatment even used for irrigation purposes, (Mustafa and Sabir, 2001; Amin and Aziz, 2005; Aziz, 2020). Due to the quick expansion in Erbil City as a result of construction a huge number of residential compounds, the extension of construction was both in vertically and horizontally direction, most of residential units are occupied by peoples displacement from middle and south of Iraq because of non-stability of political statuses, which means more and more MWW produced and added to the available sewerage system, in addition of a big development in the industrial section with a mass production factories producing Dairy Factory and Erbil Steel Company (Aziz and Saleh, 2019). All this features was covered by Sewerage system, collection and transmission but still no any approaches for treating this MWW. The work has been assessed in previous studies (Aziz and Mustafa, 2019) includes some residential compounds like Ashty City and many industrial factories, also an assessment done for the raw water in Big- Zab river to find out the amount and types of pollutants govern the river by monitoring the performance of raw water in the Water Treatment Plant of Ifraz-Unit/2 which located in Erbil, the sample taken from post-clarification processes, post-filtration processes, and from storage tanks. Also an investigation was carried out for the effects of Kawrgosk refinery wastewater (KRWW) produced on nearby water resources by comparing the traits of KRWW, big-Zab River, and groundwater (Aziz and Fakhrey, 2016).

The study performed to know how KRWW affects through monitoring and testing the surface water resources and groundwater in the area near a round the refinery and compared with the local and international standards to stand on the possibility of reuse this waters for irrigation purposes with or without treatment. Additionally, Ismael et al. (2024) investigated on Grdarasha's domestic wastewater treatment using reed beds has shown promising results in removing toxins from the environment. The system, which has low operating and maintenance costs, has shown high efficiency in removing COD, TSS, TVS, and chloride. The interplay between pollutant-plants-microbes is crucial for effective pollutant removal in this environmentally friendly method. Furthermore, Aziz and Fakhrey (2016) select the main open channel of MWW starts from center of the city at location on 40th street which consider upstream of the MWW channel collecting majorly storm water drain and continuing until downstream at appoint of in the southwest Erbil city called (Arabkand), the results showed the MWW can be used for irrigation purposes during winter were the MWW diluted with rain fall at the cold season (Bapeer, 2010). It is very clear that MWW reused directly can give view both advantages for using it which can be determined as a reliable source of water for irrigation purposes, contributing to sustainable agriculture and water conservation, and disadvantages bring about several illness and health risk to the people. On the other hand several challenges and limitations have to be addressed and studied, such as the need for advanced treatment technologies when the water quality standards are behind the allowable standards in order to ensure the quality of treated wastewater and a proper implementation of management actions and emphasis of mitigation people health and environmental risks.

2. METHODOLOGY

2.1. Study Area and Data Collection

Erbil City has hot, dry climate characterized by long, hot, dry summers and short, cool winters. January is the coldest month, with temperatures ranging from 5˚C to 10˚C, and August is the hottest month with mean maximum temperatures rising to 30˚C and more as shown in Table 1, (Kareem, and Szydłowski, 2022). About 70 % of the average rainfall in the country occurs between November and March, while June, July and August are often rainless as shown in Table 2; Data were collected at Sarkarezan Q. which is located on the left side of the Erbil- Makhmour main road in Municipality Erbil city, Kurdistan region-Iraq. Sarkarezan Q. is approximately 12 km far from Erbil city center (Figure 1). The geographical coordinates are Latitude 36° 13' 19'' N and Longitude 44° 07' 32" E., EMWW characteristics data during 4 months were collected and analyzed starts in October 2022 and ended in November 2023. Twelve MWW quality parameters such as for EMWW were collected, arranged, and compared with WW disposal standards.

Table 1: Average Temperature of Erbil (1959 to 2020), (DoW/Erbil)

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
7.1	8.3	12.1	16.3	22.7	28.2	31.8	31.6	27.5	21.7	14.9	8.9

Table 2: Average precipitation of Erbil (1941 to 2020), (DoW/Erbil)

Jan.	Feb.	Mar.	Apr.	May	JUNE	July	Aug.	Sep.	Oct.	Nov.	Dec.
84.8	76.0	79.6	55.4	22.3	0.3	0.1	0.1	0.3	11.4	39.9	76.1

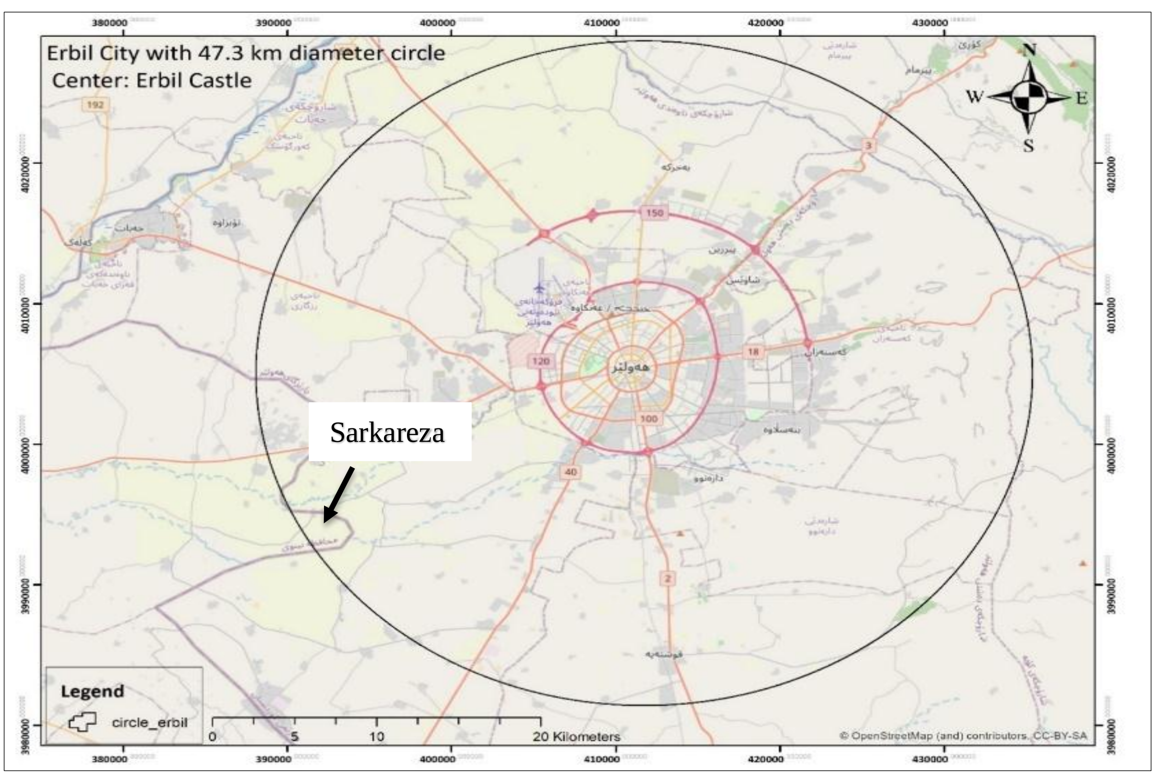

Figure 1: Map Layer of EMWW

2.2. Wastewater Management

As shown in Figure 1, the main MWW canal in Erbil City is starting from Bnaslawa Q. and passes through the land of Sarkarezan Q., which located in Erbil-Makhmour main road. As shown in Figure 2, the effluent collecting and transforming all kind of WWs and extends more than 40 km, passing through several farm lands and villages, and discharging into the Greater Zab River. In winter, the storm water drains blending MWWs, which dilutes and reduces the concentration of pollutants (Aziz, 2020). All samples captured from the site were taken to the Sanitary and Environmental Engineering laboratory in the Civil Engineering Department, College of Engineering, Salahaddin University-Erbil, Erbil, Iraq, physico-chemical analyses of WSW were carried out. The samples were handled and transported as per the standards in this regard as per .The main MWW quality parameters were tested includes, pH, Electrical Conductivity (µS/cm), TDS, Chloride, TS, Volatile, total Alkalinity, total Acidity, COD and Color. The Standard methods are used for the Examination of Water and Wastewater (Beutler et al., 2014). Titration techniques were used in experiments to measure variables including chloride, total acidity, and total alkalinity (chemical approach). The Sanitary and Environmental Laboratory's equipment were included pH, EC, and TS. For PH, PH meter used (ph/dissolved oxygen/degree ^{o}C, PD-300). Wissenschaftlich-Teshnischewerkstatten (WTW-LF42) was used to measure the EC in the samples, Spectrophotometer R2900 for COD, for Turbidity (using WT 3020 device), and for T.Alkalinity and Total Hardness (TH), Volumetric analysis used.

Figure 2: Sarkarezan's Wastewater

2.3. Water Sources in Erbil City

The availability of water resources in Erbil City is primarily dependent on groundwater, a common practice in arid regions. Overexploitation of the aquifer due to rapid urbanization and population growth has led to a significant decline in the water table, causing wells to dry up, scarcity issues, and potential conflicts over water allocation. The water source in Erbil city depends on two types such as:

2.3.1. Natural water sources

Furthermore, it is important to acknowledge the presence of natural water sources in Erbil city. The primary natural water source in the region is the Great Zab River, which originates from the Zagros Mountains, with a length of approximately 400 kilometers; the river provides a significant amount of water for irrigation and domestic use within the city. Additionally, there is numerous water springs scattered throughout the region, which contribute to the overall water availability in Erbil. These natural water sources play a crucial role in sustaining the water resources of the city and ensuring a reliable water supply for its inhabitants.

2.3.2. Groundwater resources

Another important water resource in Erbil City is underground water. Underground water refers to water that is found beneath the surface of the earth in aquifers and wells. This source of water is crucial for the city, as it provides a sustainable and reliable supply of water. The majority of the agricultural activities in term of irrigation in the around Erbil city, and some of the domestic area in the Kurdistan Region depending on ground water (Dizayee, 2018). In addition, Nanekely et al. (2017) Nanekely mentioned that groundwater is crucial and unique resource in the majority of the examined semi-arid regions because of its significant contribution to agriculture, water supply, health, and the eradication of poverty in both urban and rural areas.

2.3.3. Artificial water sources

One of the strategies to address the water scarcity issue in Erbil city is the creation of artificial water sources. These sources involve constructing reservoirs or dams to collect rainwater runoff and store it for future use. Dams such as the (Gomaspan Dam, Nazanin Dam, and Bastora Dam) have been built to store and regulate water flow, ensuring a steady supply of water for irrigation, the reservoirs created by these dams led to store a large quantities of water, which can be utilized during dry seasons and draughtiness. Additionally, underground water tanks can be installed to store water during periods of high rainfall. These artificial water sources can provide the existing water supply sources and mitigate the impact of water scarcity in Erbil city. Overall, dams and reservoirs are crucial components of water resource management in Erbil City, ensuring a reliable water supply for various purposes and contributing to the overall well-being of its residents.

3. Results and Discussions

3.1 EMWW characteristics

Table 3, present the results obtained in the laboratory for physico-chemical test of the gathered MWW samples. It is figured out some of MWW parameters exceeds the allowable amount of standards (EPA and Iraqi effluent regulations). Rising temperature will led microorganism to grow up quickly and increases their population, means more active performing biological operation in a proper way. The recorded temperature of wastewaters samples were below the permissible limits in accordance with (EPA, 2003) guidelines and Iraqi disposal standards (2011). There is temperature fluctuation during the period of the testing samples due to Weather conditions (Messrouk et al., 2014). The temperature for WW ranged between 11-23 C̊. pH parameter considered crucial factor which affects the microorganism activity in MWW. A value of pH of 6.6 is seen and gives mildly acidic which results from the decomposition of organic materials, value of maximum pH recorded of 7.7. the allowable pH value for irrigation purpose range is 6.5 to 8.4 (Amin and Aziz, 2005). The alkalinity concentration for the MWW as shown in the table 3.1 ranged from 140 to 240 mg/l as $CaCO_3$, which is behind the allowable limits (75-150 mg/l as $CaCO_3$), Other parameter is the chloride concentration for MWW, chloride (CL) sources in water are industrial effluents, which usually contains high CL concentration, also chloride flows from homes and business uses water softeners. CL values in the WSW which recorded ranged (62/80 mg/L) which is safe and within the allowable amount (750 mg/L) (EPA).In October CL was equal to 62 mg/L and the maximum value was 80 mg/l during November, High CL concentration values recorded during November and this because when in winter temperature and evaporation decreases, while the concentration during October may be attributed to dilution by rain. The range of the Chemical Oxygen Demand (COD) values in the WSW range was between (246-773) mg/L. The rise in organic waste material in sewage effluent may be responsible for the generally greatest value founded during October, which was a confirmation of the results of the dissolved oxygen test biological activity and water temperature rise; also, COD values are exceeds the allowable limits (100 mg/L). Electrical conductivity (EC) for WSW water varies from (765 to 850 µS/cm) and this is suit with the results recorded by (Abdel-Aziz and Smith, 2004; Aziz and Darokha, 2001). The lower EC values recorded (572 (µS/cm) and the higher was (756 (µS/cm) which meets the allowable limits (3160 to 6450) (µS/cm). TDS is a function of EC and their relationship is straightforward, and TDS values do not exceed 700 mg/L, which meets the allowable limits, therefore the wastewater can be considered as acceptable according to (Amin and Aziz, 2005). Another crucial quality criterion for characterizing WSW is total solids (TS). The value of TS was high and varied depending on the components of wastewater for all types of wastewater. Sarkarezan's wastewater's TS value was 432 mg/L, which was the highest value was recorded, and the lowest value of 117 (mg/L) was recorded. The types, volumes, and presence of dissolved, suspended, and colloidal particles all affect the color of the wastewater. Different type of colors is recognized due to the presence of industrial discharges (Aziz and Ali, 2017).

Table 3: Characteristics of Wastewater at Sarkarezan Q. in Erbil City

	Date	20th Oct-22	30th Oct-22	13th Nov-22	7th Dec-22	28th Dec-22	3rd Feb-23	Range	Standards
Parameters	Atmosphere temp. (^oC)	37	31	27	22	18	18	18-37	
	Wastewatertemp. (C°)	23	22	20.1	16.2	11	17.2	11-23	35*, 40**
	pH	6.6	7.7	7.78	7.3	8.2	7.7	6.6-8.2	6.0-9.5*
	EC (µS/cm)	850	838.4	809	780	765	775	765-850	3160-6450
	TDS (mg/L)	412	419	392	390	378	387	378-419	500-850
	COD (mg/L)	773	246	290	291	258	247	246-773	100*
	Chloride (mg/L)	62	78	80	75	79	78	62-80	750**
	TS (mg/L)	400	400	348	432	200	117	117-432	20-500
	Volatiles (mg/L)	35	73	29	121	100	117	29-121	
	T.Alkalinity (mg/L)	140	232	232	232	240	178	140-240	75-150
	Acidity (mg/L)	71	56	68	36	20	21	20-71	40
	Color (Pt. Co.)	156	232	331	376	258	603	156-603	Nil*

* Iraqi Environmental Standard (2011)
** Environmental protection regulations (EPA) (2003).

3.2. Municipal Wastewater Management

In order to evaluate the significance of the study for the purpose of wastewater reuse in Erbil city, it is crucial to highlight and understand the status of the water quality and quantity, also the challenges poses against Erbil city in terms of water scarcity and the increment of the population. There is a need for review the wastewater management strategies taking into consideration the limited freshwater sources and a massive growing population as mentioned before; the need for alternative water sources becomes paramount. Wastewater reuse has emerged as a viable solution to meet the increasing water demands while also addressing the issue of water scarcity. By studying wastewater reuse in Erbil city, researchers can identify the potential benefits, risks, and implications of this practice for irrigation purposes and gives valuable insights and view for decisions makers to take proper actions in water management and urban planning. The effluent of MWW sometimes used for direct irrigation purposes without going through any treatment process in Erbil; this may be acceptable if the water quality of WW are within the permissible limits and there will be no any significant risk for reuse this WW for irrigation purposes or landscape in spite of some negative indicators as bad smells. Untreated WW has negative impacts on the environment, human health and water supply resources. As a part of applying an integrate water management for Erbil city and as a starting, there is an opportunity to use the wastewater for the design of parks such as fountains or irrigating types of agriculture productions after the first treatment, this step will led not to use underground water for irrigation and to be used only for water supply within a proper plan in case of lack of using surface water supplies (Aziz and Fakhrey, 2016) and in turn will we can protect groundwater and prevent water shortages occurs in Erbil. Also there is a possibility in the advance good management implementation to inject surpass treated water directly to underground to assist in rising underground water table level. Researchers found that whereas EMWW is good for irrigating landscapes and part of special crops, While WSW in Erbil City was not safe for all types of irrigation (Amin and Aziz, 2005). Naturally, treating EMWW with different systems reduces impurities like organic matter, suspended solids, nitrogen compounds,…, etc (Aziz, 2020). The COD, TSS, and pH values for treated EMWW show that water can be used for cooked vegetables, parking lots, playgrounds, and the sides of city roadways. The BOD_5 and TSS values for treaded EMWW can be used for irrigation purposes for certain crops. Therefore, a careful and systematic approach is needed to ensure the safety and efficiency of wastewater reuse operations.

3.3. Problems and Solutions of Water Resources in Erbil City

3.3.1 Problems

Implementation of wastewater management in Erbil city faces two major obstacles which needed effective solutions; firstly, lack in treating of MWW, due to inadequate infrastructure and limited resources, no adequate technologies available in Erbil city, all MWW is discharged in to the body of water without any treatment results a serious health for public health, the other face of this problem is using this untreated water in irrigation and unhealthy agriculture products considered big risk for public health. Secondly, the utilization of fresh water for landscape and irrigation purposes which increase the water scarcity were the fresh water instead to provide the community with used in landscaping and irrigation purposes. The consequence this aspect is well known now a days in term of the huge increment of the population due to displacement and refuges movement from inside Iraq and out Iraq respectively because of the instability of political status in to the Kurdistan Region especially Erbil City, it may be this aspect considered temporary and looking to be addressed in future. . Another problem results from the limited capacity of the water resources especially in Big-Zap River to meet increasing demands and environmental concerns due to population increment. The drought governs last years due to an extensive climate change were the rainfall dropped by 15% over the earlier 15 years. The same aspect is recognized in the drawdown of underground water table levels during this 15 years, the deficit reached 250 to 300 meters resulted from using underground water without a clear plan for agriculture purposes and providing water for new residential cumulative (AhmedKhoshnaw and Karpuzcu, 2018). Therefore, it is crucial to assess the existing wastewater management practices and identify areas for improvement to ensure sustainable and safe reuse of wastewater for irrigation in Erbil city.

3.3.2 Solutions

The main solution for the problems addressed in the earlier article is to establish an extensive water management strategies, the plan should be applied for each problem and finding a proper solution and linking all of them in one main linkage. The solution can be summarized as below:

- Increasing and retrofit the existing surface water supply and sewerage collection system

for the community, includes extension and rehabilitation to minimize water losses and wastewater infiltration, this will contribute in solving the increment in using underground water (Wells).
The local authorities should prevent using fresh water in the irrigation purposes especially in the areas around urban.

- Effective WSW treatment, establish treatment plant with advance technologies to turn the treated water to such extend for reusing it for landscaping, irrigation purpose and injecting it into underground water. On point should be emphasises, we cannot use purified water for agricultural and irrigation parks since the amount of water (both surface and groundwater) is declining. This action will solve the problem of reusing WW in agriculture purpose. Currently, the wastewater treatment methods used in Erbil city in very small capacities (limit units) for certain building which not considered for public services and coverage the total sewerage system are mainly based on conventional. However, these methods have several limitations insufficient removal of certain contaminants such as heavy metals and pathogens (Sankhla, 2016). They also have the potential to improve the sustainability and efficiency of wastewater treatment in Erbil city. In this regard, KRG finished a project of WW treatment plant for Erbil city with a huge capacity (200 m^3/d), now it is in the tendering process, this project also contribute in producing Chemical fertilizers and manufacturing electricity. This leads to a more sustainable and environmentally friendly agricultural system. Furthermore, monitoring and assessment protocols should be implemented by KRG to evaluate the impact of wastewater irrigation on soil and crop quality, as well as potential health risks for farmers and consumers.
- Construction of several artificial rechargers as mentioned earlier in order to ameliorate the water which contribute in and to arising underground water and increasing sourced used for agriculture. The building of subsurface dams, as well as other aquifer management and regulation techniques, have been devised and some of them implemented (Nanekely and Scholz, 2017)
- Proper distribution of residential areas in side Erbil city in term of providing adequate water supply in a base of the daily capital water demand and close monitoring for the infrastructure soundness, also construction new sewerage system to collecting WW for treatment.

4. Conclusions

In conclusion, Erbil city produces huge amount of MWW daily (200 m^3/d), the study showed the nature of the characteristics of MWW and it's counted as mild to medium strength through analysing the MWW quality parameters, WSW used for irrigation purposes and it creates risk for public health, major produced MWW not treated, in few locations, small WW plant available governs. Based on the MWW quality results can be effectively treated and used for irrigation purposes without posing significant health and environmental risks. Proper MWW management needed to eliminate the risk of MWW, disposal and usage, this step need close monitoring from KRG which started in establishing WW treatment plant (Tendering process stage), also KRG started in construction many artificial water recharges (Dams) for both rising underground and irrigation purposes. KRG adapted stringent regulation to control the WW pollutant and increasing public awareness. Furthermore, monitoring and assessment protocols for long-term effects should be implemented by KRG to evaluate the impact of wastewater irrigation on soil and crop quality, as well as potential health risks for farmers and consumers

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