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Evaluate the efficiency of al-Mukalla Wastewater Treatment Plant

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Abstract
The projects of the sewage treatment plants in Hadramout are considered one of the most important infrastructure projects, but this treatment plant was suffer from many problems resulting from inefficiency in operating the current projects. The objective of this research is to evaluate the treatment efficiency and the quality of treated wastewater in accordance with the international specifications [BOD_5(<10 mg/l), TSS (<5 mg/l), pH (6-8.5), E.coli (<10 org/100 ml) which works with the system of oxidation ponds.[8]. Laboratory analyzes and periodic measurements were carried out in April and May of 2022 for biochemical oxygen demand (BOD_5=308 mg/l), total suspended solids (TSS=6.02 mg/l), pH (pH=5.8), dissolved oxygen (DO=3.33), and E.coli =13 and some other results are not logic explained in tables below. The results showed that the efficiency of the treatment is weak and there are problems in the operation and maintenance of the plant such as there are no a fixed period for the entry of wastewater into the plant, there are no maintenance of the network lines that influent and effluent from the plant, screeners are not work, there are no device to measure flows at the influent and effluent of the station, there are no lab. in the station to measure all these parameters. Therefore, numerous strategies have been studied to raise the performance efficiency. The recommended upgrade strategy was found to do some treats to return the station to normal and give good efficiency in treatment.
Keywords
Wastewater treatment plants, biochemical oxygen demand (BOD),total suspended solids (TSS),ph(pH),dissolved oxygen(DO) and E. coli, almukalla.

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I. Introduction

Wastewater treatment is of a great importance as it reduces pollutants and diseases, especially in developing countries with a high level of health awareness. Several methods have been chosen in the past years to treat wastewater, and all methods have a positive effect to reduce wastewater pollutants, but the local climatic conditions and economic conditions preferred a certain method for wastewater treatment. Comparisons between treatment with oxidation ponds and other methods indicated that treatment with oxidation ponds is better than treatment with other methods, from an economic point of view. [4].

Oxidation ponds are the simplest ways ever to treat sewage and industrial waste. These lakes are created in simple engineering ways that sometimes do not go beyond excavation work. Treatment takes place in these lakes in a natural way that depends on an integrated joint activity carried out by algae and bacteria with the help of sunlight and some elements that are already present in sewage. Oxidation lakes are usually used for small flows, but it is not forbidden to use them for large flows when sufficient areas of land are available at an affordable price. [6].

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The main parameters affecting oxidation ponds performance are temperature, quantity and direction of wend, pH, density of sunlight, quantity of DO, characteristics of wastewater that would be treated.

The common operation problems of oxidation ponds are it needs a large areas, the spread of unpleasant odors and mosquitos, high content of suspended solids, loss of a large amount of water due to evaporation, groundwater pollution due to infiltration, and this is related to the permeability factor.

II. Methods and tools

This research aims to evaluate the efficiency of the Al-Mukalla wastewater treatment plant, and whether this station works to treat the collected sewage water from almost all pumping stations (lifting) that are collected from all the wastewater of al-Mukalla city and its environs, as well as the wastes of West Mukalla (Fawah).

Table (2.1) samples in the anaerobic ponds:

Sample information				tests results					
The sampling site	Day	Date	Time	Temp.^{0}C	pH	DO	TSS	BOD_5	E-Coli
A1	Don't work								
A2	Tuesday	10-4-2022	5:00	33.3	7.27	0.08	8.11 mg/l	659 mg/l	<23
A3	Tuesday	1-5-2022	5.14	33.7	8.96	0.00	4.11 mg/l	568 mg/l	<23

The followed methodology of this research included the site suitability and the type of employed treatment, in addition to the collected information from the personnel. Based on the conducted necessary analysis in an environmental college lab. Proper strategies have been studied to develop an outline assessment of the MWTP to upgrade the performance and alleviate the obtained deficiencies. [3].

2.1. Location of the study area

Hadramout Governorate is located in the east of the Republic of Yemen and occupies 36% of its area. Hadramout consists of 30 districts, and its capital is the city of Al-Mukalla, and its largest city. Saudi Arabia is bordered from the north and from the south by the Arabian Sea, from the northwest by the governorates of Ma'rib and Al-Jawf, from the east by Al-Mahrah Governorate and from the west by Shabwa Governorate. Hadramout governorate area is a bout 190,000 km^2 and its population is about 930,000 capita.

The study area is the coastal region of Hadramout Governorate in the Republic of Yemen, which enjoys the presence of many coastal valleys whose waters flow into the Arabian Sea during periods of rain only, and currently most of them go to the sea without benefiting from them. There are a limited number of treatment plants, including the sewage treatment plant in the city of Al-Mukalla works on the road to Oxidation Lakes, where this station is located west of the city of Al-Mukalla in the Embekha region, but unfortunately there are several problems and obstacles facing the treatment plant, and therefore we searched for problems and a number of necessary analyzes were made, so this study comes to know the performance of the efficiency of the treatment plant.

Fig. 2.1 shows aerial photos of the site of the Embekha treatment plant in the city of Mukalla

III. Al-Mukalla Wastewater Treatment

3.1 The site of the sewage treatment plant for the city of Al-Mukalla

Choosing the appropriate site for the wastewater treatment plant is to obtain the place that can be developed in the future without prejudice to the conditions of environmental protection laws, and when it has an impact on the surrounding environment, it must be very limited.

Considerations for choosing a location for wastewater treatment plants:

1- It is preferable that the location of the sewage treatment plants be relatively high from the rest of the neighboring lands to protect it from rain and floods.
2- The treatment plants should be at least 500 meters away from the city and the scope of service areas in the assembly network, and it is required that there be a buffer zone between the site and the residential areas.
3- Not to choose the location of the treatment plants so that any unpleasant or distinctive smells are transmitted to the city or the population center.
4- The proposed place for the treatment plants should be located on a paved road so that equipment and operating requirements for the plant can be transported easily.
5- The selection of the site should be such that its area is sufficient for current works and future expansions for at least 50 years.
6- It is preferable that the location of the treatment units be as close as possible to the agricultural lands that can use the surplus in rail operations.
7- It is preferable that the location of the treatment units be near the farms so that the resulting liquid and dried sludge after treatment can be utilized by using it as municipal fertilizer.[2].

- The treatment plant is located west of the city of Al-Mukalla in the Embekha Valley, and the site of the station was chosen high above sea level for the following reasons:

• Reducing earthworks and grading basins.
• The movement of water from the basins by slopes.
• The exit of water, after treatment, to the alternative line for draining water into the sea.[3].

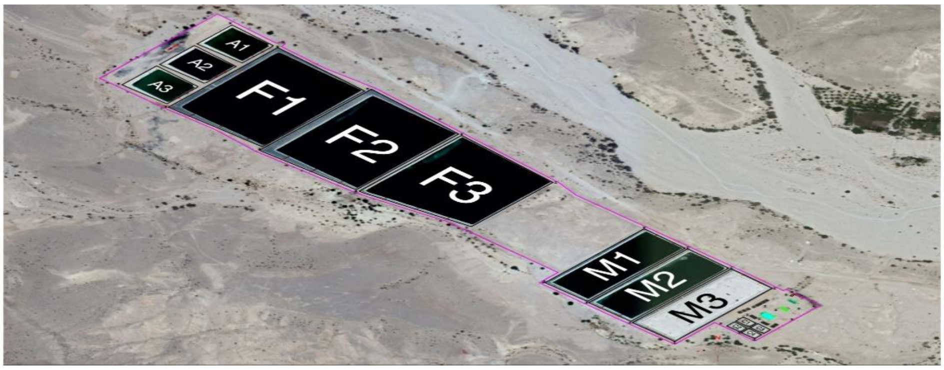

Fig. 3.1 An aerial view of the station

3.2 Oxidation Ponds

3.2.1 Advantages of oxidation ponds

1. It can be operated in many ways
2. Construction, operation and maintenance in this way are done at the lowest cost
3. Accommodating sudden changes in hydraulic and organic loads
4. It is suitable for treating many types of industrial waste
5.The concentration of total dissolved substances decreases as a result of treatment in the oxidation ponds.[6].

3.2.2. Dis-Advantages of oxidation ponds

1. The spread of unpleasant odors and mosquitoes
2. High content of suspended solids
3. Loss of a large amount of water due to evaporation
4. Groundwater pollution due to infiltration, and this is related to the permeability factor.[6].

The system of al-Mukalla wastewater treatment plant relies on the traditional system for treating wastewater, which is oxidation ponds or what is called biological treatment, which are open basins with large areas that rely on microorganisms to oxidize and collect dissolved and small suspended organic materials in wastewater.

Oxidation ponds contain large earthen ponds in which wastewater is held for fixed days to undergo removal of both organic content and suspended solids. Oxidation lakes can be used in one stage or in a group of stages, either in sequence or in series. [1].
The oxidation ponds were arranged in the Al-Mukalla sewage treatment plant in Wadi Ambikha , in series, with the following names: primary ponds, secondary ponds, and optional ponds. shown in Figure (3-1).
Primary ponds, known as (**anaerobic ponds**), receive raw sewage from the sewage network to the treatment plant. Most of the suspended solids are disposed of in these basins to collect and sediment biologically. Secondary ponds, known as (**facultative ponds**), where the soluble organic content of wastewater settles. **Maturation ponds** or **aerobic ponds** are used to improve the overall performance of the pond system and eliminate pathogenic materials from wastewater.

3.3 Components and contents of the Mukalla treatment plant (Imbikha Area)

as shown in Fig.(3.2) the MWTP consists of three anaerobic ponds (A1*A2*A3)/each, followed by three facultative ponds (F1*F2*F3)/each, and finally three maturation ponds (M1*M2*M3)/each. These ponds treat about 540 l/s of sewage(three pumps each one of them are pump the wastewater to the plant about 180 l/s); serving around 930,000 capita. The necessary other units of head works (screen, grit chamber), as well as electric generators are existing. The treated effluent is discharged into the sea according to the employed standards in Yemen.

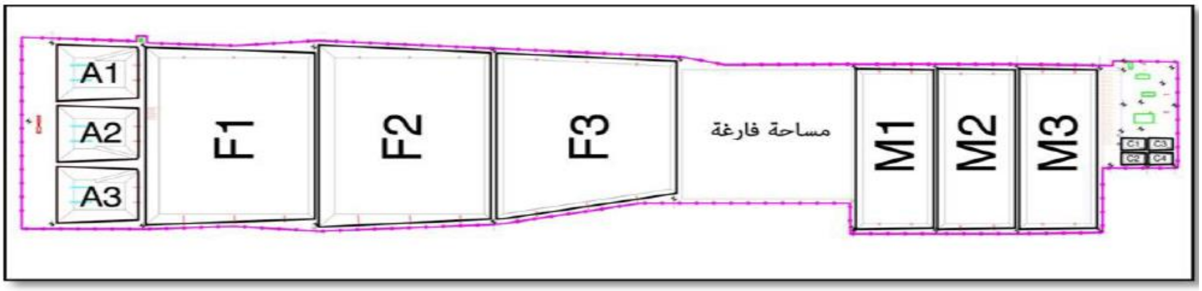

Fig. 3.2 Plan of Mukalla Station

3.3.1 Screeners:

To seize floating and suspended foreign materials in sewage water (such as pieces of cloth, wood, etc.) in order to preserve the following units. [5]. The screens at the MWTP are manual (Fig. 3.3), i.e., cleaned by labors periodically.

Fig. 3.3 The work of the filters and the tool used to filter the filters from sus. materials.

The screeners at the Mukalla wastewater treatment plant operate in the traditional way or what is called the manual method. The workers clean the suspended materials in the screener in a regular manner.

3.3.2. Anaerobic ponds

In it, anaerobic bacteria use the oxygen present in some compounds to oxidize organic matter, in the absence of dissolved oxygen in the water. The rates of oxidation by aerobic bacteria are faster than oxidation by anaerobic bacteria, but they need dissolved oxygen in the water. Usually, the anaerobic analysis of sewage begins after it remains in the sewage networks for about 4 hours. On this basis, in large cities that are served by sewage networks with large lengths of lines, the sewage reaches the treatment plants in a moldy form, and it may need an initial aeration process. prior to processing operations.

Anaerobic ponds can treat high organic load because dissolved oxygen is not present, i.e. photosynthesis. It is recommended that stay periods in anaerobic lakes not exceed five days, so that the length of stay in The ponds cause the anaerobic treatment process to become an aerobic treatment. On the other hand, the design was placed on to does not exceed the volumetric load of 400 g $BOD_5/m^3/d$ to avoid odor problems. Anaerobic ponds are deep ponds, with a depth of 2.5 to 5 meters. It shall be equipped with a convenient outlet in and out, to conserve heat and energy and maintain air conditions. [7].

Fig. 3.4 A picture of anaerobic ponds

3.3.3. Facultative ponds

There are earthen basins and usually consist of three regions: the surface region, the middle region and the bottom region. The main design criteria employed in the facultative ponds are the surface load of 40 g $BOD_5/m^2/d$ and the retention time which is not less than 5 days.

Fig. 3.5 Anaerobic aerobic basins

3.3.4. Maturation Ponds

It is also called Aerobic Pond. These lakes receive the liquid waste coming out of the aerobic / anaerobic lakes, and their depth ranges from 1.0-1.5 m. Its primary function is to remove harmful microorganisms. Its efficiency is mostly low for removing BOD because it receives wastewater with low dissolved BOD5, for example the water coming out of aerobic/anaerobic lakes has a dissolved BOD5 content between 50-70 mg/L (expected to drop to 25 mg/L or less in the case of the Mukalla treatment plant). This is after treatment in one lake and two of the ripening lakes.[7].

Fig. 3.6 Ripening tanks

3.4. Problems of Al- Mukalla treatment plant

3.4.1. Reducing the quantity of water flowing into the station

One of the problems that have been noticed since the start of work on the project to evaluate the treatment plant in the city of Al-Mukalla in the Ambikha region is the lack of pumping hours coming to the treatment plant and also the irregular pumping hours during the day, and this leads to a decrease in the flow of the amount of sewage entering the treatment plant and thus a decrease in the Efficiency of the treatment process in the ponds.

A. Stopped the Sewage pumping in several areas

- The interruption of sewage pumping for the Mukalla, Al-Dis, Al-Sharj and Ibn Sina areas, and the pumping of sewage water was limited to the affected areas, Al-Masaken, Fowah Al-Kadima and Al-Inshaat areas.
- Recently, the line coming from the Ibn Sina station to the lift station of the treatment plant was repaired and reconnected, but the official pumping of the station has not yet been resumed.
- The sewage water of the city of Mukalla is cut off at the station located in the Shibam round due to problems occurring in the line carrying the sewage water to the lifting station of the treatment plant.

B. The amount of wastewater that received from the Motadarereen areas, Al-masaken, old fowah and Al-Enshaat.The quantity of wastewater coming to the pumping station.19 in the Ba-gersh area, which carries liquid waste to the treatment plant, is very small and does not cover the needs of the treatment plant to carry out the correct treatment process.

C. Measuring the quantities of incoming and outgoing flows to the station

There is no meter in the treatment plant to measure the amount of raw sewage flowing into the treatment plant, due to the breakdown of the equipment in the plant when it started working due to the deterioration of maintenance work. Figure (3.7) shows the out-of-service flow meter at Mukalla station.

Fig. 3.7 The flow meter at Mukalla station

D. Duration of Pump

There is a program for pumping the liquid wastes of sewage water from the lifting station to the treatment station. It was prepared in coordination with both workers in the lifting station and the treatment station, but due to reasons (a) and (b), this program is not implemented.

E. Laboratory

There is a laboratory in Al-Mukalla treatment plant, but unfortunately it is empty. There are no measurement and examination devices for samples taken from the ponds. Therefore, there is difficulty in measuring the treated water standards. The result of the measurement may also change during the period of transferring the sample to an external laboratory.

3.4.2. Duration of residence of wastewater inside the basins

Oxidation lakes depend on the residence period of wastewater for certain and studied periods to carry out the effective treatment process. In the Mukalla treatment plant, the residence times vary in an irregular and unconsidered manner for several reasons.

a. Low amount of water entering the sewage treatment plant Al-Mukalla city Like what was previously mentioned in Paragraph 3-1 due to the low amount of sewage water for the station, which constitutes a change in the residence times in the basins.

b. Random operation of the station

Due to the lack of a qualified technical staff to carry out the operation of the station, random operation of the station occurs, including changing the residence periods without making the necessary calculations.

3.4.3. Quality control and quality

There is no correct and accurate monitoring of the sewage entering and leaving the water treatment plant due to the lack of readiness of the laboratory in the station.

a) Failure to complete the equipping of the laboratory located inside the station with the appropriate equipment to carry out the necessary tests for the sewage water entering and leaving the station.

b) Failure to carry out wastewater tests, which leads to the inability to know and determine the efficiency of the plant in treating wastewater.

3.4.4. Technical staff

The staff at the wastewater treatment plant for the city of Mukalla needs training to manage the station and carry out wastewater treatment work. There is no specialized staff in this field.

a. Random operations of the station for stay operations.

b. There are no qualified technical personnel to conduct quality and quality audits of wastewater.

3.4.5. Maintenance

Maintenance One of the advantages of the wastewater treatment plant in the oxidation basins is the lack of operation and maintenance, but the lack of good maintenance of the station led to the deterioration of the station in an unexpected way

1. The station's lack of regular maintenance operations and its outages because of that
2. There are no maintenance workers at the station to carry out maintenance work.
3. The station needs equipment for pond maintenance work.

3.4.6. No sludge landfill

A cleaning was made for one of the anaerobic ponds by removing the sludge deposited at the bottom of the basin, and the sludge removed from the basin was collected and piled near the anaerobic ponds, which causes the following problems:

1. Environmental pollution and exposure of sludge to air, which increases the possibility of transmitting diseases.
2. Possibility of sludge returning to the basins indirectly, such as wind or rain, which may wash away the accumulated sludge to the basins.

3.4.7. Ponds protection

There is no protection around the basins to protect them from the entry of dirt and slippery stones from the side of the road.

3.4.8. Changing the color of the pond water

It was noticed that the color of the water changed from one basin to another, starting with the first basins, which are the anaerobic basins.

The color of anaerobic ponds tends noticeably to green, and this is due to the proliferation of algae in them. It is noted that the amount of algae is very large.

IV. Tests and results

4.1 Tests for liquid waste samples

Some physical, chemical and biological tests are conducted to examine a sample of wastewater in order to estimate its concentration before treatment. The same tests are also conducted on a sample of liquid waste during and after treatment. By comparison, all treatment processes can be inferred, including tests.[3].

4.2 Laboratory tests performed:

The tests were conducted in the laboratory of the College of Environment due to the lack of a laboratory inside the sewage treatment plant in Mukalla city. Among the most important chemical tests that were conducted for wastewater samples taken from the ponds were the BOD, total suspended solids (TSS), pH, and oxygen. The dissolved DO, and normal tests were carried out, such as measuring the temperature of the basins, and a biological test was performed, which is to know the number of Escherichia coli bacteria, and it is symbolized by E-Coli.

4.2.1 Biological Oxygen Demand (BOD):

It is the amount of oxygen consumed by microorganisms in the aerobic oxidation of organic matter in a dilute sample of sewage kept at a temperature of 20°C for five days.

The BOD is considered one of the most important measures on the basis of which all liquid waste treatment plants are designed, and it is an accurate indicator of the efficiency of biological treatment processes.This test is useful in determining the organic loads of the raw liquid waste disposal and is considered one of the required factors in the design of treatment processes. It helps in identifying organic pollutants when disposing of wastewater from water bodies after treatment to ensure compliance with environmental protection laws. This test gives a general idea of the efficiency of operating processing operations and modifying operating methods to improve their efficiency. [3].

4.2.2 Total Suspended Solids (TSS):

They are the solid particles associated with feces found in sewage and responsible for odors. The concentration of suspended matter is one of the most important elements of the design criteria for treatment units.

4.2.3 pH:

It is the pH that determines whether the liquid is acidic or alkaline. A neutral liquid, such as water, has a pH of 7. Mazda is considered a basic liquid, and what decreases is considered acidic.

4.2.4 Dissolved Oxygen (DO):

It is a relative measure of the amount of dissolved or carried oxygen in a specific medium. This percentage can be measured by a dissolved oxygen probe such as a sensor or an oxygen sensor.

4.2.5 Escherichia coli (E.coli):

It is one of the most important types of bacteria that live in the intestines of mammals. It is a negative bacterium that inhabits the large intestine in humans. The presence of this bacterium in the surrounding medium indicates fecal contamination, so it is often used as evidence of water pollution.[3].

4.3 Sampling method

Samples were taken directly from the ponds at the treatment plant in the city of Al-Mukalla on four field trips, and three samples were taken in each descent, with the tests that were conducted on the ponds directly.

Method of taking the sample from the pond:

A random method was used to take the sample because there was no technology or special equipment to take a wastewater sample from the basins, so the random method was characterized by using a bucket and a rope randomly thrown into the basin, then the samples were withdrawn and taken from the bucket and placed directly inside the samples boxes taken from the laboratory and previously sterilized. The sample is usually taken against the outlets of Each basin. [8].

Fig. 4.1 How to take a sample from the basin

There are disadvantages to this method, including:

i. The place of taking the sample is inconsistent each time, as the sample may be superficial and sometimes it may sink to the bottom, which causes imbalance and inaccuracy, so the results of the samples vary due to the conditions of sampling.

ii. This method is only feasible in places close to the sides of the pond and cannot be used to take samples from the middle of the pond.

4.4 Types of tests:

There are laboratory tests conducted inside the laboratory of the College of Environment under the supervision of a laboratory technician, and there are field tests conducted directly on site by the project team on the basins using mobile laboratory equipment, and the project team has been trained to use them by the laboratory technician.
There are two main types of tests that were conducted:

4.4.1 Laboratory Tests:

The process of receiving samples from the laboratory of the College of Environment is carried out by the laboratory technician, and this is done immediately after sampling from the station. The samples are kept in the cooler until the experiment is conducted.

A. Total Suspended Solids (TSS) Experiment

Total suspended solids in seawater and wastewater are determined according to APHA (1998). 100ml of water sample is filtered through a 0.45 µm membrane filter paper (Whatman), then the filter paper is dried at 100 ± 50 °C, then cooled in desiccators and weighed. In order to obtain realistic data, free of salt interference from seawater, the filter is thoroughly washed with distilled water. [8].
The total suspended solids (TSS) value is calculated using the following formula:
TSS ((mg)/L)=(W-F*1000)/(Sample Volume (ml))
where:
W = weight of filter paper + residue in filter paper after drying (mg)
F = filter paper weight (mg)

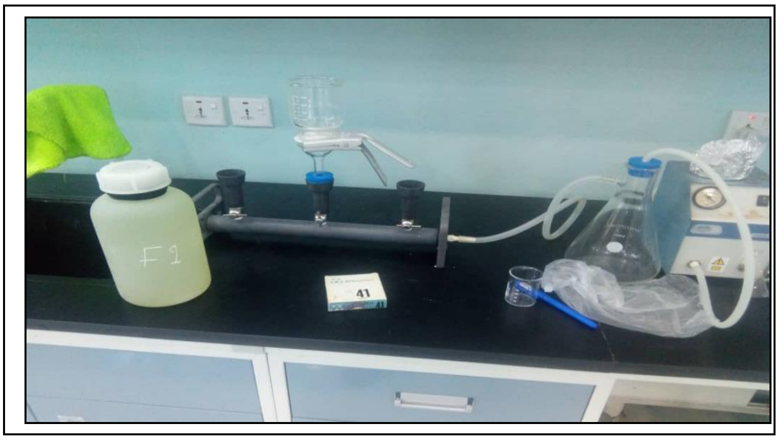

Fig. 4.2 is a picture of the TSS device

B. **Biological Oxygen Experiment (BOD_5)**

Biological oxygen consumption (BOD_5) is a measure of the oxygen used in bacterial oxidation of organic matter in water and wastewater (Kale and Mehrotra, 2009). BOD_5 was measured by (Velp Scientific FOC225E-Refrigerated Incubator) as shown in Figure (4.3).
The BOD determination was carried out using 150ml (APHA (1998)) distilled water was added to 150ml of water sample in the BOD bottle. The sample is placed inside the BOD device. Where the sample is incubated in the dark for 5 days at 20 ° C, to prevent the production of a large amount of dissolved oxygen in the sample through photosynthesis. The concentration of dissolved oxygen in the sample is determined by comparison to the control sample. [8]. Then the demand is calculated as follows:

BOD5 = (D1 - D2) / P

where:
D1 = dissolved oxygen per sample immediately after preparation (mg/L).
D2 = dissolved oxygen per sample after 5 days incubation (mg/L).
P = decimal fraction of the sample size used

.

Fig. 4.3 A picture showing the BOD device

C. Escherichia coli:

Estimating low numbers of E. coli bacteria by using the (Most Probable Number (M.P.N) method). To do this test, MPN is commonly applied to test water quality, i.e. to make sure that the water is safe or not in terms of the bacteria present. In which. A group of bacteria commonly referred to as fecal coliforms acts as an indicator of fecal contamination of water. The presence of very few faecal coliform bacteria indicates that the water probably does not contain disease-causing organisms, while the presence of high numbers of fecal coliform bacteria indicates a very high possibility that the water could contain disease-producing organisms making the water unsafe. Safe to consume. And the principle of testing the most probable number method (M.P.N) The water being tested is serially diluted and inoculated with lactose, And in the case of coliforms in the water using the lactose in the medium to produce acid and gas. Referred The presence of acid is indicated by a color change in the medium and the presence of gas is detected as gas bubbles collected in an inverted Durham tube are present in the medium. The number of total coliforms is determined by counting the number of tubes that give a positive reaction (i.e., color change and gas production) and comparing the pattern of positive results (the number of tubes that show growth at each dilution) using standard statistical tables. Figure (4.4) shows the division of the sample in the laboratory tubes to conduct the experiment. Table (4.1) also shows an example of a standard statistical table.

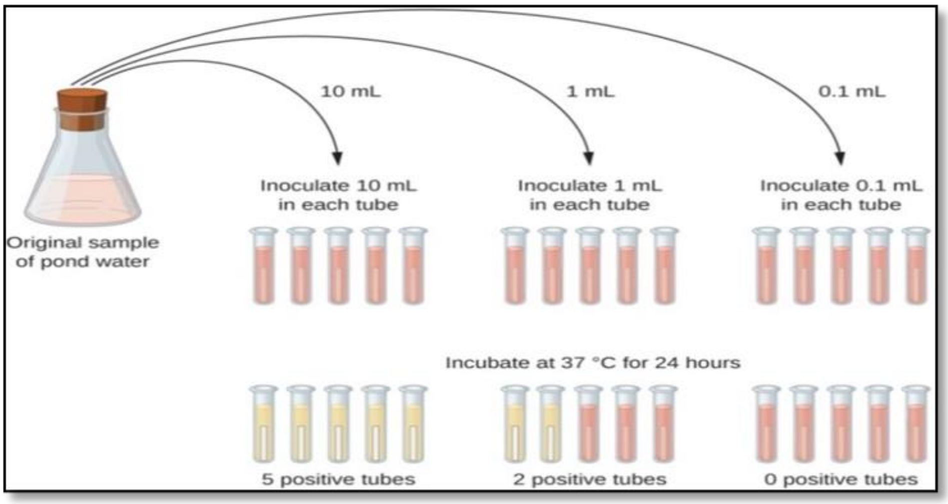

Fig. 4.4 divide the form of the test to choose E-Coli.

Table:4.1 for a standard statistical table for the E-coli test

MPN values per 100 ml of sample and 95% confidence limits for various combinations of positive and negative results (when five 10-ml, five 1-ml and five 0.1 ml test portions are used)

No. of tubes giving a positive reaction :			MPN (per 100 ml)	95% confidence limits	
5 of 10 ml	5 of 1 ml	5 of 0.1 ml		Lower	Upper
0	0	0	<2	<1	7
0	1	0	2	<1	7
0	2	0	4	<1	11
1	0	0	2	<1	7
1	0	1	4	<1	11
1	1	0	4	<1	11
1	1	1	6	<1	15
2	0	0	5	<1	13
2	0	1	7	1	17
2	1	0	7	1	17
2	1	1	9	2	21
2	2	0	9	2	21
2	3	0	12	3	28
3	0	0	8	1	19
3	0	1	11	2	25
3	1	0	11	2	25
3	1	1	14	4	34
3	2	0	14	4	34
3	2	1	17	5	46

4.4.2 Field Tests

Field experiments were conducted at the Mukalla sewage treatment plant for some field tests from the ponds, which consisted of measuring the degree of hydrogen ace, PH, dissolved oxygen, and measuring temperature.

Method of conducting field experiments

Use a field portable device (HORIBA – PH /DO METER D-55) shown in Figure (7.4) to measure the pH, dissolved oxygen and temperature directly from the oxidation pools

.

Fig. 4.6 The field device (HORIBA – PH/DO METER D-55)

- Use a field portable device (Global water Instruments 1-800-876-1172) to measure the incoming sewage flow to the plant. Figure (12.5) shows the shape of the device.

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Fig. 4.7 Discharge Flow meter

V. Results and Analysis:

Tables (5.1) to (5.4) show the results of the following tests conducted at the Mukalla city station for the treatment of liquid waste for a number of field visits. The table includes laboratory and field results. Temperature measurement test, pH measurement, resolving oxygen, total suspended solids and E-Coli test.

Table (5.1) Results of the First descent

First descent									
Sample information				tests results					
The sampling site	Day	Date	Time	Temp.^{0}C	pH	DO	TSS	BOD_5	E-Coli
A2	Tuesday	10-4-2022	5:00	33.3	7.27	0.08	8.11 mg/l	659 mg/l	<23
F1	Tuesday	10-4-2022	5:15	32	8.89	6.34	9.69 mg/l	456 mg/l	<23
M1	Tuesday	10-4-2022	5:15	31.8	8.74	0.11	11.51 mg/l	312 mg/l	16

Table (5.2) Results of the second descent

Sample information				tests results					
The sampling site	Day	Date	Time	Temp.^{0}C	pH	DO	TSS	BOD_5	E-Coli
A3	Tuesday	1-5-2022	5.14	33.7	8.96	0.00	4.11 mg/l	568 mg/l	<23
F1	Tuesday	1-5-2022	5.47	32	6.82	1.19	5.21 mg/l	523 mg/l	<23
M2	Tuesday	1-5-2022	6.04	32.9	5.80	3.33	6.02 mg/l	308 mg/l	13

Table (5.3) Results of the third descent

Third descent									
Sample information				tests results					
The sampling site	Day	Date	time	Temp.^{0}C	PH	DO	T.S.S	BOD_5	E-Coli
Station entrance	Tuesday	8-5-2022	11.08	33.8	7.07	33	22.3 mg/l	639 mg/l	<23
F1	Tuesday	8-5-2022	12.02	33.5	6.52	4.12	10.23 mg/l	445 mg/l	<23
F2	Tuesday	8-5-2022	12.15	34.5	6.49	4.88	12.4 mg/l	488 mg/l	19

Table (5.4) Results of the fourth descent

Fourth descent									
Sample information				tests results					
The sampling site	Day	Date	Time	Temp.^{0}C	PH	DO_2	T.S.S	BOD_5	E-Coli
Station entrance	Sunday	13-5-2022	10:55	34.1	6.14	0.0	13.7 mg/l	678 mg/l	<23
F1	Sunday	13-5-2022	12:04	33.7	5.54	4.78	291 mg/l	423 mg/l	20
F2	Sunday	13-5-2022	12:14	34.1	2.1	2.81	9.98 mg/l	412 mg/l	15

5.1 Biological Oxygen Demand (BOD_5) Concentration:

The BOD content is an estimate of the amount of biodegradable organic matter by determining the amount of oxygen used by anaerobic bacteria to degrade the biodegradable organic matter. This indicator is considered one of the most important indicators of foamy and dissolved organic pollution, which constitutes a burden on biological treatment units. Table (5.5) shows the results of the BOD incoming to the station.

Table (5.5) concentration of water samples water supply.

BOD_5 mg/l	**Concentrate the BOD before treatment**			
	Time	**Date**	**day**	**The sampling site**
639	**11:08**	**8/5/2022**	**Tuesday**	**Station entrance**
678	**12:10**	**13/5/2022**	**Sunday**	**Station entrance**

The permissible limit for untreated wastewater entering the station should not exceed (600 mg /l) it reduces the efficiency of the station in the disposal of organic components.

Table (5.6) Concentration of BOD samples in Maturation ponds

BOD_5 mg/l	**Concentration of BOD in Maturation ponds**			
	Time	**Date**	**day**	**The sampling site**
312	**05:15**	**10/4/2022**	**Tuesday**	**M1**
308	**06:04**	**1/5/2022**	**Tuesday**	**M2**

The ripening ponds are considered the last stage of the sewage treatment process in the Mukalla station due to the cessation of the work of the chlorine ponds. The concentration of BOD shown in Table (5.6) is high compared to the final value of the treated water used in agricultural irrigation. The concentration of bio-oxygen consumed is less than 20mg/l. In accordance with the standards of the US Environmental Protection Agency (2006). [3].

5.2 Total Suspended Solids (TSS)

The process of conducting a total suspended solids (TSS) experiment for basins was carried out in the laboratory of the College of Environment as shown in Table (5-1) to Table (5-4). The results show two problems.

a. The station failed to get rid of the total suspended solids. As noted in the first table (5.5), the TSS value in the anaerobic basin (A2) is low, and after that the value increases in the ripening basin (M1), which is impossible to happen if the treatment is working properly. Because anaerobic ponds are supposed to get rid of the majority of the total suspended solids.

b. All the results from Table (5.5) to Table (5.5) are incorrect because the results of the (TSS) do not appear with small values in the manner shown, and it may be an error from the laboratory and the error was not detected.

5.3 pH

Figure (5.1) shows a set of pictures showing the team's work to take field test readings.

a. The results of the first descent:
Bacterial activity reaches its maximum at PH = 7. In the first anaerobic basin A2, we found that the result was PH = 7.27, and in basin F1 the result was PH = 8.89. Decomposition of organic matter, and in the last ponds (maturation lakes) M1, we found a value of PH = 8.74.
b. The results of the second descent:
In the first basin A3 we found a value of PH = 8.96, this is evidence that the bacteria are not active, and in the second basin F1 the value of PH = 6.82 and this indicates that the bacteria are active and in the ripening basin M2 the value of PH is equal to 5.8 and this is evidence that the bacteria are active decomposing organic matter.
c. The results of the third descent:
We conducted the examination from the inside directly to the station and we found the value of PH = 7.07. This is evidence that the bacterial activity is at its maximum. In the second basin F1 the value of PH = 6.52. organic matter.
d. The results of the fourth descent:
We conducted the examination from the inside directly to the station and we found the value of PH = 6.14. This is evidence that parasites are increasing and decomposing organic matter. In the second basin F1 the value of PH = 5.54. This is evidence that parasites are increasing and decomposing organic matter. In basin F2 the PH value is 2.81 and this is evidence The parasites increased.

Fig. 5.1 Pictures showing the work of the team to take the readings

5.4 Escherichia coli:
The results of the Mukalla wastewater treatment plant showed the presence of Escherichia coli bacteria in large numbers, as in Tables (5.1) to Table (5.4). These results indicate that the water is unsafe and that the water may carry diseases, and therefore the water is considered unfit for use.

5.5 Measurement of station incoming flow:
The amount of flow entering the station through the Parshall channel was measured. Through the flow measurement device (Global water Instruments 1-800-876-1172) Figure (5-2) shows, we noticed in the first reading on Tuesday 8/5/2018 at 10:55 am that the flow is weak, equal to 0.10 m3 /s. The second reading was on Sunday 13/5/2018 at 11:00 am, that the flow is weak, equal to m3/s. 0.07

Fig. 5-2 Flow measurement

VI. Discussion/Conclusion:

We note by comparing the results in measuring each of (BOD_5 - TSS - pH - DO - E.coli) that all of them are logic and do not comply with international standards in treatment. This means the failure of Al-Mukalla wastewater treatment plant and because of the problems we mentioned earlier, the plant's efficiency has become very weak.

6.1 Recommendations:
6.1.1 Recommendations for the entity responsible for the station:

The General Directorate of Water and Sanitation must take a number of important measures and matters, which are summarized as follows:

I. Must to Re-opertate and maintain the left stations for the regions of Al-Mukalla and Ibn Sina into the service to increase the rates of discharge.
II. must to Determine a fixed period for the entry of wastewater into the plant to stay in the basins for the period necessary for it to allow the bacteria to carry out the treatment process and analyze the organic matter naturally.
III. Must to Maintenance of the network lines that influent and effluent the plant due to the interruption of flows for long periods.
IV. Must to Re-repair the filters in the lift station 19 so that impurities and suspended materials are removed through these filters.
V. prefer to put a device to measure flows at the influent and effluent of the station to know the flow rates
VI. Equipping the station's laboratory with the necessary equipment to carry out the necessary tests for water at the station.
VII. Re-operating the chlorine unit and rehabilitating it so that we can obtain water suitable for reuse.
VIII. Providing tools, materials and parts necessary for operation and maintenance.
IX. Qualifying the station staff on operation and maintenance through training courses.
X. Training station staff on occupational safety and necessary health directives.
XI. Create protection around each basin to keep it from entering dust and rainwater.

6.1.2 Recommendations for station personnel:

There are a number of obligations for treatment plant operators:

a. Proper operation of the wastewater treatment plant to obtain water according to specifications and standards.
b. Maintenance of equipment, buildings and land.
c. Maintenance work for the station periodically to avoid any problems and qualifying
d. a staff specialized in maintenance work
e. Ensure to follow up the quality and preserve the environment by conducting periodic tests for the plant on a daily, weekly, monthly and annual basis to assess and determine the efficiency and quality of the treated water.
f. Carrying out the necessary studies to determine the residence times in anaerobic lakes, anaerobic aerobic lakes, to obtain water with the required specifications and standards.

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