Laundry Wastewater Characterization and Treatment for Reuse Purposes in Muscat, Oman

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Abstract The present study aim and focuses on a comparative study for the cleanup of laundry wastewater characteristic from domestic and commercial sources in Muscat, Oman. The laboratory analysis performed to investigate the effluent quality parameter from commercial and domestic of laundry water for ten run cycles for the parameters of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solid (TDS), Total Suspended Solids (TSS), Turbidity, Electrical Conductivity (EC), Dissolve Oxygen (DO), Copper (Cu), Iron (Fe), Magnesium (Mg), Hardness, Temperature. Sand filter is used to upgrade the effluent quality to comply with the Omani standards for discharge of non-housed liquid waste into sewage system. The results show that the range of pH for domestic wastewater (DW) and commercial wastewater (CW) is 6 to 9 and 9 to 11 respectively. The values of chemical oxygen demand (COD) of DW vary form 500-1200 mg/l while for CW range from 300-900 mg/l. Furthermore, Total suspended solid (TSS) is in the range of 200-500 mg/l for DW and 800 up to 1100 mg/l for CW. The average of iron and copper approximately for DW 0.1 and 0.08 mg/l for CW 0.18 and 0.15 mg/l respectively. The biochemical oxygen demand (BOD) in DW is in the range of 40-460 mg/l and for CW is in the range of 80-220 mg/l. The results obtained for turbidity for DW and CW is in range 20-200 NTU and 10-200 NTU respectively. Treatment of laundry wastewater by sand filter involved collection of wastewater in storage tank where the wastewater pass through the sand filter by gravity upon vertical system. The adequacy of the treated laundry wastewater was assessed by Caledonian College of Engineering (CCE). Commercial color cloths wastewater treated by sand filter shows the removal of approximately 30% for TSS, 70% for TDS, and turbidity 20%. The result of this study shows that all wastewater quality parameters, (pH, TSS, TDS, Turbidity, Electrical conductivity, Temperature, DO, Hardness, Fe, Cu, Mg) are complied with Omani standards for discharge of non-housed liquid waste into sewage system. As consequence, the discharge of the laundry liquid waste from commercial and domestic has no impact on the wastewater facilities in Muscat.

Key words: Wastewater, Treatment, Laundry, Samples, Characteristics, Reuse

1. Introduction

The issue of water resource management and the provision of water for the population is one of the major challenges facing the world. The need for human usable water in the world has increased which may lead for water shortages in the future. From this concept one of most critical issue is consumption of laundry water, where huge quantities of water used for washing every day (Massoumeh .M, Ali Kargari, 2016). Laundry wastewater is type of gray water where this water contain soap, suspended solids, oil, perfumes, and other high concentrations of chemicals (Juliana Braga, Maria B.V, 2014) .This research introduce to find a solution regulation consumption of laundry wastewater where report discuss the procedure for treatment laundry wastewater as well as the expected time for project, aim, objectives, methodology and the lliterature review of the previous study done related to this project.

Converting the laundry wastewater to treated water through several processes in order use it for several domestic applications. In point view of the specialists "Generally, laundry wastewater treatment serve the society which have positive effect and several advantages" (Juliana Braga, Maria B.V, 2014). This ensure the important of this project.

Project will be specified in Muscat region, the domestic wastewater samples will be collected from home in Al Mawaleh area, samples will be collected for different type of cloths such as white cloths, black cloths, color clothes, on the other hand commercial wastewater samples will be collected from Al Ghafat express laundry in Al Khoudh area and type of cloth, white and color.

The concept of the project is to solve consuming of laundry wastewater furthermore to reuse the water for other purposes. According to ministry of regional municipalities and water resources the pie chart 1 shows water usage statistics in the Sultanate of Oman. The agricultural sector is the main user of water in the Sultanate with a total consumption of 78%. followed by other sectors. From the concept of the project best practice is to treatment and reuse the domestic and commercial of laundry water for agriculture and other priority purposes in order to development of natural water resources and increase recovery rates as well to reduce amount of the wastewater and protect the environment. (MRMW, 2014).

pie chart 1: Main sectors of water uses in Sultanate of Oman (MRMW, 2014)
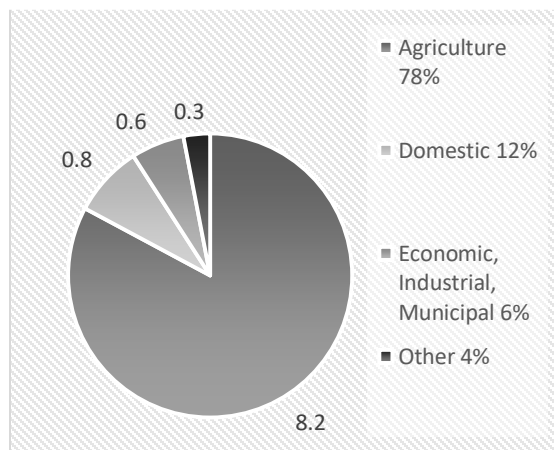
2. Experimental & Design

2.1 Materials

The quality parameters of the wastewater will be investigated and the materials requirement will be according to standard methods. These materials required will be identify thought the experimental process.

2.2 Area Selection

The project will be depending of the area selection where this project will be conduct in Muscat area. For commercial laundry the location of the shop in Al-Khoudh area by dealing with Al Ghafat Express Laundry and for domestic laundry the location in Al-Mawaleh area.

### 2.3 Collection the Samples and Estimation of Volume

Collection of the samples will be through commercial and Domestic laundry for different type of wash cloths such White Cloths wash, Black Cloths wash, Color Cloths wash and Mixed Cloths wash. The collection will be from automatic washing machines moreover, the wastewater was obtained from washing a mixture of daily adult and children clothes.

For the domestic the linear water level in the wash machine vary from 36 L up to 100 L the average used at house is from 60 L - 82 L. Time taken for every cycle wash from 30 - 90 minutes depend on the water flow power process as well as types of clothes. Clothes washed about each two days or three days. For the commercial the linear water level in the wash machine reach up to 100 L or more. Clothes washed daily. Samples collection is scheduled for one week and for evaluate the quantitative and qualitative one week.

2.4 Test the water characteristics

After sample collection immediately, the analyses will be performed at a Caledonian laboratory. "The analysis used to characterize wastewater vary from precise quantitative chemical determinations to the more qualitative biological and physical determination" (Massoumeh .M, Ali Kargari, 2016). Thirteen parameters investigated for five wash cycles of domestic and commercial laundry water. The characteristics of water test will be followed by Ministry of Environment and Climatic Affairs (MECA). Time expected for samples analyses are from two to three weeks.

Hierarchy 1: Purpose of Waste Water Characteristic
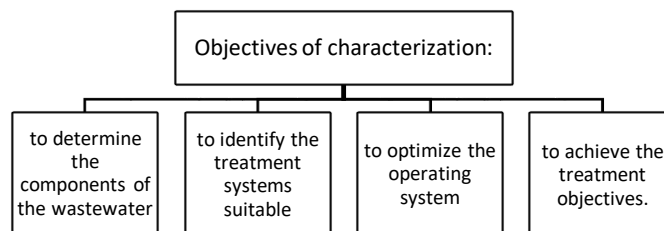
2.5 Selecting Treatment Process

After chemical analysis is performed sand filter is selected for treatment process where it consists of wastewater cylinder tank placed at top followed by square sand filter that include 5 layers then square sand filter attached with extra small cylinder that consist of 3 layer and at the end collection treated wastewater tank to be placed. In fact, sand filters is used as a step in the water treatment process of water purification. Sand filters is a good option for limited budget operations as the filtration is not using any chemicals and requires little or no mechanical assistance. During the process of filtration, raw water can percolate through the porous sand medium, stopping and trapping organic material, bacteria, viruses and cysts such as Giardia and Cryptosporidium.

Figure 1 Layout of the of project
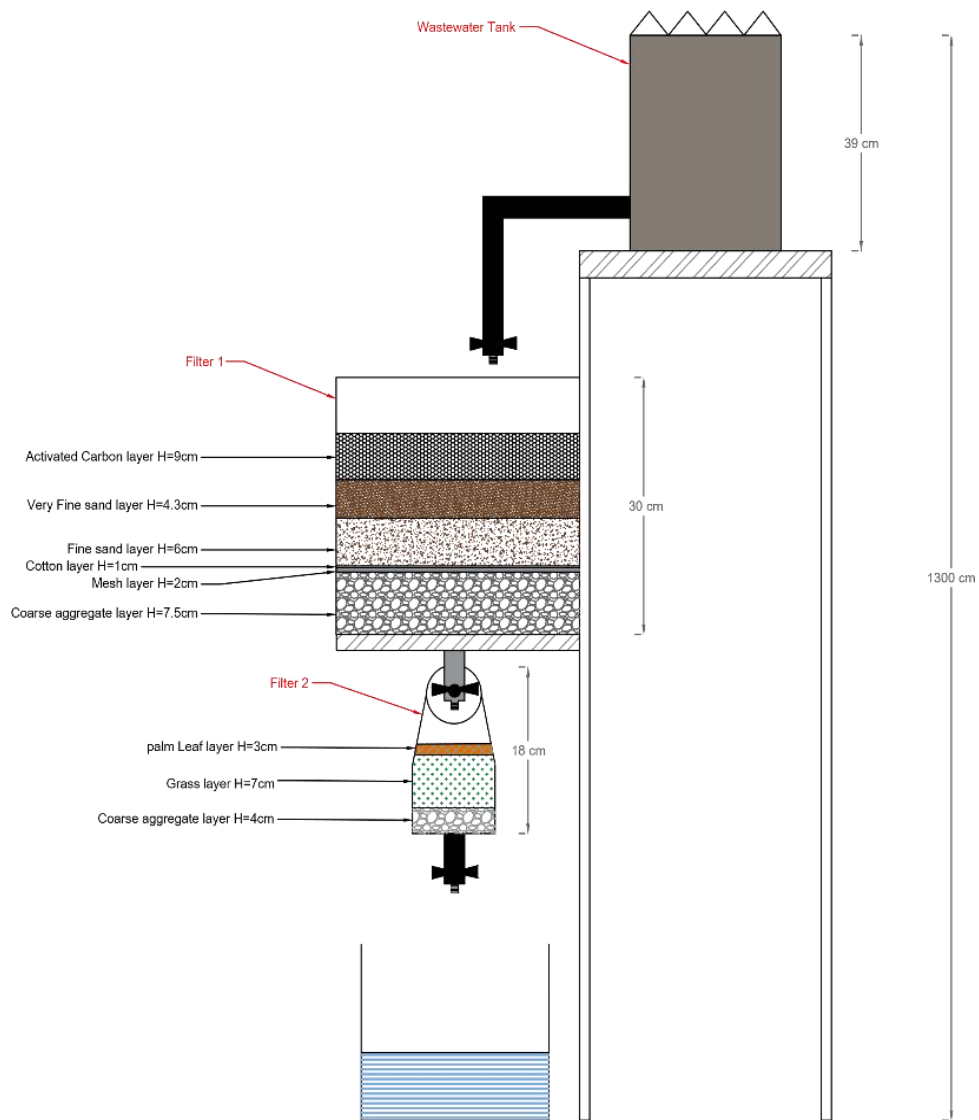
3. Results and Discussions

3.1 Results

3.1.1 Laboratory Analysis for Domestic Laundry Wastewater (Wash Cycle One)

Table 1 Domestic Laundry Wastewater Samples

Type of clothes: White		Type of clothes: Color		Type of clothes: Black	
Parameter	Result	Parameter	Result	Parameter	Result
pH	7.74	pH	7.49	pH	6.79
TSS	450 mg/l	TSS	525 mg/l	TSS	260 mg/l
TDS	2000 mg/l	TDS	1400 mg/l	TDS	428 mg/l
Turbidity	40.4 NTU	Turbidity	135 NTU	Turbidity	32.8 NTU
Electrical conductivity	5.76 mS/cm	Electrical conductivity	4.91 mS/cm	Electrical conductivity	1.56 mS/cm
Temperature	23.2 ℃	Temperature	22.8 ℃	Temperature	24.5 ℃
DO	0.58 mg/l	DO	5.65 mg/l	DO	2.73 mg/l
COD	997 mg/l	COD	1007 mg/l	COD	1204 mg/l
BOD	50 mg/l	BOD	80 mg/l	BOD	40 mg/l
Hardness	115 mg	Hardness	250mg	Hardness	119 mg
Iron	0.06 mg/l	Iron	0.15 mg/l	Iron	0.90 mg/l
Cu	0.05 mg/l	Cu	0.16 mg/l	Cu	0.02 mg/l
Mg	0 mg/l	Mg	0.1 mg/l	Mg	0 mg/l

3.1.2 Laboratory Analysis for Commercial Laundry Wastewater (Wash Cycle One)

Table 2 Commercial Laundry Wastewater Samples

Type of clothes: White		Type of clothes: Color	
Parameter	Result	Parameter	Result
pH	10.85	pH	10.44
TSS	814 mg/l	TSS	1116 mg/l
TDS	6380 mg/l	TDS	8849 mg/l
Turbidity	150 NTU	Turbidity	91.9 NTU
Electrical conductivity	13.80 mS/cm	Electrical conductivity	4.11 mS/cm
Temperature	22.3 ℃	Temperature	23.2 ℃
DO	5.3 mg/l	DO	1.2 mg/l
COD	755 mg/l	COD	323 mg/l
BOD	80 mg/l	BOD	220 mg/l
Hardness	100 mg	Hardness	-
Iron	0.10 mg/l	Iron	0.19 mg/l
Cu	0.01 mg/l	Cu	0.06 mg/l
Mg	0 mg/l	Mg	0

3.1.3 Analysis of Treated and Untreated of Commercial Laundry Wastewater for (Color Cloth Sample)

Table 3 Untreated of Commercial Wastewater

Untreated sample characteristic	
Parameter	Result
Color	Yes
pH	10.44
TSS	1116 mg/l
TDS	8849 mg/l
Turbidity	112 NTU
Electrical conductivity	4.11 mS/cm
DO	1.2 mg/l
Iron	0.19 mg/l
Cu	0.06 mg/l
Mg	0

Table 4 Treated of Commercial Laundry Wastewater

Treated sample characteristic	
Parameter	Result
Color	Reduced
pH	9.04
TSS	789 mg/l
TDS	8780 mg/l
Turbidity	91.9 NTU
Electrical conductivity	4.27 mS/cm
DO	1.1 mg/l
Iron	0.25 mg/l
Cu	0.07 mg/l
Mg	0

3.1.4 Quantities Estimation producing out of Domestic and commercial Wastewater

Table 5 Volume Estimated for One Wash Cycle

	Domestic			Commercial	
Types of clothes	White	Color	Black	White	Color
Estimated Quantity (in)	60 L	82 L	60 L	100 L	100 L
Estimated Quantity (Out)	49 L	69 L	44 L	86 L	78 L

4. Discussions

4.1 Omani Standard

Comparison results found of treated laundry wastewater with Omani standard (Standard for discharge of non-household liquid waste into sewage system according to Ministry of Environment and Climate Affairs).

Table 6 Standard for discharge of non-household liquid waste into sewage system
according to Ministry of Environment and Climate Affairs

Components	Standards
pH	6-10
Colour	Raises no objection
Biochemical Oxygen Demand (5 days)	Not more than (1000) mg/L
Chemical Oxygen Demand	Not more than (1500) mg/L
Temperature	Not more than 43C0
Suspended solid	Not more than (1000) mg/L
Total dissolved solids	Not more than (3000) mg/L
Copper (expressed in tons of copper)	Not more than (1) mg/L
Iron (expressed in tons of iron)	Not more than (5) mg/L
Unpolluted water (including condensation and cooling water and water drained from roofs of buildings).	Not seen
Insecticides, herbicides, pesticides, fungicides	Imperceptible
Any substance (whether by itself or with any other substance allowed to be discharged into sewage system).	Imperceptible
Any material that may render wastewater harmful or makes formal treatment of such waste difficult.	Imperceptible

There is significant reduction in parameters such as pH, TDS, TSS, Turbidity, EC, DO, Iron, Copper of Commercial Laundry Wastewater of color clothes treated using sand filter as shown in result table 15. It can be observed that by using sand filter there was color reduction as well as effective in reducing laundry wastewater parameters, in addition the physical – chemical analysis is within the MECA standard. It can be conclude that discharge of laundry wastewater after treatment by sand filter have no effect on sewage system furthermore for high level treatment sand filter can be attached with additional technique of treatment such as ultra-filtration, electrocoagulation and many other methods.

5. Conclusion

From this study it can be concluded that chemical and physical characteristic analysis conducted at Caledonian laboratory for the parameters (COD, TSS, Fe, Cu, Mg, Turbidity, EC, DO, Hardness) as well some of parameters such as (BOD, TDS, pH, Temperature) conducted at A Seeb wastewater treatment plant laboratory are complied with complied with Omani standards for discharge of non-housed liquid waste into sewage system.

This study shows that the range of pH for domestic wastewater (DW) and commercial wastewater (CW) is 6 to 9 and 9 to 11 respectively. The values of chemical oxygen demand (COD) of DW vary form 500-1200 mg/l while for CW range from 300-900 mg/l. Furthermore Total suspended solid (TSS) is in the range of 200-500 mg/l for DW and 800 up to 1100 mg/l for CW. The average values of iron and copper are approximately for DW 0.1 and 0.08 mg/l for CW 0.18 and 0.15 mg/l respectively. The biochemical oxygen demand (BOD) in DW is in the range of 40-460 mg/l and

for CW is in the range of 80-220 mg/l. The results obtained for turbidity for DW and CW is in the range of 20-200 NTU and 10-200 NTU respectively.

Present study analysis domestic and commercial laundry wastewater produced upon separation of cloths for example white, color, and black cloths. Characterization of this study compared with the literature review where it can observe that there is an urgent need for more information about the characteristics of laundry wastewater in addition laundry water studies had no consistent characteristics, and the content of parameters varied from sample to sample with taking in the account different conditions that may affects the analysis.

The tradability study of laundry wastewater is carried out to investigate the removal efficiency by sand filter. This study involved collection of wastewater in storage tank where the wastewater pass through the sand filter by gravity upon vertical system. The adequacy of the treated laundry wastewater was assessed by Caledonian College of Engineering. Commercial color cloths wastewater treated by sand filter shows the removal of approximately 30% for TSS, 70% for TDS, and turbidity 20%. The result of this study shows that all wastewater quality parameters, (pH, TSS, TDS, Electrical conductivity, Temperature, DO, COD, BOD, Fe, Cu, Mg) are complied with Omani standards for discharge of non-housed liquid waste into sewage system. As consequence, the discharge of the laundry liquid waste from commercial and domestic has no impact on the wastewater facilities in Muscat.

6. Recommendations/Future Work

This project can be expansion for other areas not only Muscat as well test the parameters such as BOD, COD, TSS, PH, and Turbidity can be conducted in professional laboratory and the treatment processes can be progress with high efficiency apparatus that will give better effluent results according to national standards. In addition to improve this project in the future years filtration device tank can be manufactured with high standards specification and it can be install at every house for recycle laundry wastewater with separate connection sewage networks of laundry water and link directly with filtration device tank which will used for several applications.

Figure 2 Recommended Layout Process
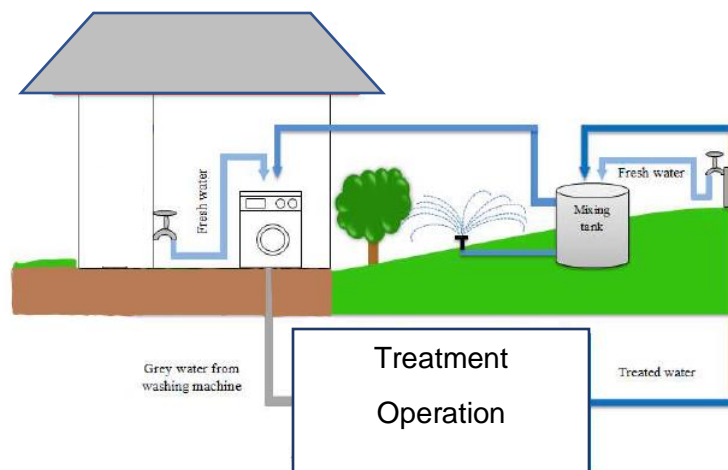
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