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Quantity and quality of screenings and grits removed from wastewater treatment plants in Palestine

كمية ونوعية المواد المُنَخَّلة والحصى المنزوعة في محطات معالجة مياه الصرف الصحي في فلسطين

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Supervisor

Prof. Dr. Nidal Mahmoud

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This thesis was prepared under the supervision of Prof. Dr. Nidal Mahmoud and has been approved by all members of the examination committee

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اهداء

الى وطن الشهداء فلسطين

الى قدس الاقداس اولى القبلتين وثالث الحرمين

الى كل شهيد روى بدمائه الطاهرة الارض المقدسة

الى كل اسير واسيرة خلف القضبان ضحو بعمرهم من اجل القضية

الى ابي وامي، اقرب الناس على قلبي , الى من علموني العطاء ,الى من سهرو الليالي ، الى من ضحو بعمرهم من اجلي ، الى من كانا الداعمان الاساسيان في اكمال مسيرتي التعليمية، والدي الاعزاء اطال الله بعمركم

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الملخص

تصف الأدبيات المتاحة على نطاق واسع المراحل الأولى والثانية والثالثة لمعالجة مياه الصرف الصحي البلدية،ولكن تم إيلاء القليل من الاهتمام لمرحلة المعالجة الأولية، أي المناخل وغرف إزالةالحصى. ان عدم وجود جهد بحثي غير مبرر لأن المعالجة الأولية هي مرحلة مهمة للغاية،ولاسيما في البلدان النامية حيث لا تكاد توجد أيمعلومات موثوقة حول كمية ونوعية المواد التي يتم إزالتها في هذه المرحلة. الهدف الرئيسي من هذا البحث هو توفير معلومات حول كمية ونوعية الحصى والمواد المُنَخَّلة والتي يتم إزالتها في ثلاث محطات رئيسية مختلفة لمعالجة مياه الصرف الصحي في الضفة الغربية / فلسطين،وهذه هي محطات الطيرة والبيرة وأريحا في ظل التركيبة السكانية السائدة والموقع الجغرافي والمناخ السائد والبنية التحتية الموجودة. نتائج هذا البحث مهمة ليس فقط لفلسطين ولكن أيضًا للدول الأخرى ذات الخصائص الديموغرافية والجغرافية والبنية التحتية الضعيفة

كان العمل عبارة عن بيانات ومعلومات التي تم جمعها من المحطات الثلاث وتنقسم هذه المعلومات الى قسمين ،القسم الاول الكمي حيث تم اخذ ثلاث قراءات على الاقل لتحديد الكميه المنتجة لكل منخل ومزيل الحصى في الثلاث محطات,القسم الثاني النوعي حيث تم اخذ ثلاث عينات بحجم 1 لتر لكل عينه من كل منخل ومزيل حصى بالمحطات الثلاث بمجموع 30 عينه (12عينه محطه اريحا ،9عينات محطه البيرة ، عينات 9 محطه الطيرة) وتحليل هذه العينات وعمل فصل لها وحساب الكثافة ونسبه المياه.وكانت النتائج الكميه على النحو التالي في محطه الطيرة كان مجموع النفايات المخرجة اليومية 19.6 كيلوجاف والنفايات المخرجة السنوية لكل فرد 0.1 كيلوجاف وكميه النفايات المخرجه لكل متر مكعب مياه عادمه هي 7.84 جرام اما في محطه البيرة فكان مجموع النفايات المخرجة اليومية 178.7 والنفايات المخرجة السنوية لكل فرد0.9 كيلو وكميه النفايات المخرجه لكل متر مكعب مياه عادمه هي 29.77 جرام وفي محطه اريحا كان مجموع النفايات اليومية المخرجة 47 كيلو والنفايات السنوية المخرجة لكل فرد 0.67 كيلو وكميه النفايات المخرجه لكل متر مكعب مياه عادمه هي 19.6 جرام. اما بالنسبة للنتائج النوعية فيمكن تلخيصها بان عينات المناخل ومزيل الحصى تحتوي اكثر من 65 % ماء وان كثافتها تتراوح من 500 الى 800 غم لكل لتر وان الكثافة الجافه تتراوح بين (100-250) غم لكل لتروان نوعيه المواد المزالة هي بلاستك، قماش، اوراق، مواد عضويه، قش، خشب، مكسرات، اقماع سجائر ،زجاج، حجارة صغيرة وتربه وهذه النتائج موضحه بشكل مفصل في جزء النتائج والمناقشة لكل منخل ومزيل حصى بالمحطات الثلاث.

Abstract

The available literature describe extensively the primary, secondary and tertiary stages of the municipal wastewater treatment, but little attention is given to the preliminary treatment stage screens and grit removal chambers. The lack of research effort is not justified because the preliminary treatment is very important stage, and particularly in developing counties, there is hardly any reliable information about the quantity and quality of material removed in this stage. The main goal of this research is to investigate the quantity and quality of grit and screenings removed in three main different wastewater treatment plants in the West Bank/ Palestine, namely Al-Tira, Al-Bireh, and Jericho WWTP under the prevailing specific demographical, geographical, climatologically and infrastructure status. The results of this research are not only important for Palestine but also for other countries with similar demographic, geographic features and poor infrastructure.

The experimental work was divided into two parts, the first is quantity where three readings at least taken from each size of screens and grits in three WWTP, second is quality where three sample size 1 liter take from each size of screen and grit with total 30 samples (12 samples in Jericho, 9 samples in Al-Bireh, 9 samples in Al-Tira) and characteristic of this sample and calculate density, dry density, percent of water and percent of solid. The result of quantity part (kg/d dry, kg/c/d dry, kg/m^3) in Al-Tira is (19.4 kg/d, 0.11 kg/c/y, 7.84 kg/ m^3), in Al-Bireh is (178.7 kg/d, 0.9 kg/c/y, 29.77 kg/ m^3), and in Jericho is (47 kg/d, 0.67 kg /c /d, 19.6 kg/ m^3). The results of quality part can be totaled most samples has water percent more than 65 % and density between (500 - 800 g/l) and dry density between (100-250)g/l and combustion of material removed is plastic, paper, clothes, organic material, straw, wood, nuts, cigarette, some of glass, small stones and soil. The results show in details in result and discussion section for each size of screens and grit removal.

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Chapter one

Introduction

In order to save life and clean environment, all effort must be combined in reducing the continuous pollution of the environment. Wastewater and solid waste management is a key challenge facing the world because when disposed untreated or partially treated cause severe human and environmental threats. The adverse impacts of poor wastewater management are particularly clear in the third world countries (Raschid-Sally, 2013). However, national and international efforts are increasingly exerted to treat wastewater adequately. In Palestine, waste water treatment plant have been designed upon assumptions of wastewater characteristics and amount of flow because no any data is available. (Nashashibiand van Dijl,1995).

The process of wastewater treatment must be divided into four main stages. The first stage is called a preliminary treatment, and its goal is to remove large objects and grits. The second stage is called a primary treatment, and its goal is to remove large suspended organic solids. The third stage is called a secondary treatment, and its goal is to degrade organic matter by biological treatment. The fourth stage is called a tertiary treatment, and its goal is to further improve the effluent quality before being discharged (Prakash, 2019).

Though wastewater treatment plants are great interventions for environmental protection, the WWTP themselves contribute to a number of negative environmental impacts because of energy consumption, usage of chemical compounds, and finally yet importantly, the production of byproduct wastes that ought to be properly managed including screenings, grit and sludge. The solid waste such as screenings and grit are removed from operation of preliminary treatment stage had been little attention in literature (Sidwick, 1991).

The preliminary treatment is composed of screening unit followed by a grit removal chamber. The screening unit is the first element in waste water treatment plant and it is used to remove large objects like rags, paper, etc (Hanben, 1999; Mansour-Geoffrion, 2010; Kuhn and Gregor, 2013). The large objects removal is important to prevent clogging pipes, damaging pumps, blocking valves, hangover weirs, and so reduce plants operation and maintenance problems

(Demun, 1994). The screens consist of bars or perforated plates of various shapes and openings size. The material taken away by these devices are named screenings (DIN, 2007).

The available literature describe extensively the last three stages of wastewater treatment, namely primary, secondary and tertiary stages, but little attention is given to the preliminary treatment stage, i.e. screenings and grits (Le Hyaric*et al.*, 2009; CadavidRodríguez and Horan, 2012 & 2013).). According to Kuhn and Gregor (2013), screenings removed in WWTPs are given little attention by wastewater technologists and researchers. The lack of research effort is not justified because the preliminary treatment is very important stage, and particularly in developing countries, there is hardly any reliable information about the quantity and quality of material removed in the preliminary treatment stage (Prakash, 2019The available literatures about preliminary treatment provide general descriptive information about the function of the screens and grit removal chambers.

The quantity and quality of screenings depend on many factors like type of equipment, operating conditions, type of the sewer system (combined or separate), geographic site, population habits, size and type of catchment area and number of upstream pumps (Kuhn and Gregor, 2013). In Palestine and similar developing countries, the poor solid waste collection is another factor that probably influence the quantity and quality of screenings.

Constituents in wastewater like sand, cinder, gravel, shattered glass and similar substances of settling velocity significantly higher than organic are termed grit (EPA, 2003; Davis, 2010). A number of technologies exist that remove grit from influent sewage as aerated grit chamber, vortex type grit chamber, and detritus horizontal tank (Prakash, 2019).

Grit Removal prevents damage of pumps and abrasion of pipes and mechanical equipment (Ullah, 2016). Like screenings, the grit quantity and quality is influenced by the type of technology, operating condition, type of sewer system (combined or separate), geographic site, population habits, size and type of catchment area and number of upstream pumps (Kuhn and Gregor, 2013). The semi-arid climate in Palestine and similar developing countries could be another factor that might have impact on the quantity and quality of grit (Shadeed, 2008). This factor could increase the percentage of sand and other types of soil entering the sewer networks.

It is crucial to determine the quantity and quality of this material to apply a satisfactory treatment and disposal methods. The published research results reveal that the most popular used system to disposal screenings and grit are land filling and incineration as well (Hyaric, 2010). Nevertheless, land filling is the least preferable choice in waste management advised by the European and national legislations, and so should be applied when there is no other available alternative (EU, 2008).

1.1 Problem statement

The quantity and quality of grit and screenings removed in the wastewater treatment plants of the West Bank/ Palestine with its specific geographical, climatological and infrastructure status have not been investigated. The available information in literature about the screenings and grits quantity and quality is rare, and limited to general descriptive information.

1.2 Research questions

The following key questions are addressed in this study:

1- What are the quantities of material removed by the screens in three selected WWTPs in the West Bank/Palestine?
2- What are the type and properties of the material removed by the screens in three selected WWTPs in the West Bank/Palestine?
3- What are the quantities of grit removed by the grit removal chambers in three selected WWTPs in the West Bank/Palestine?
4- What are the types and properties of grit removed from grit removal chamber in three selected WWTPs in the West Bank/Palestine?

1.3 Overall objective

The key goal of this research is to determine the quantity and quality of grit and screenings removed in three waste water treatment plants in the West Bank/ Palestine, namely Al-Tira, Al-Bireh, and Jericho WWTP under the prevailing specific demographical, geographical, climatological and infrastructure status.

The specific objectives of this research are to:

1- Determine the specific amount of removed screenings (L/d, Kg/d, L/c/y, kg/c/y, L/m^3, Kg/m^3) in the three different WWTPs.
2- Determine the specific amount of removed grit (L/d, Kg/d, L/c/y, kg/c/y, L/m^3, Kg/m^3) in the three different WWTPs.
3- Categorize the various constituents of screenings removed in the three WWTPs (type of material, water content and density)
4- Categorize the various constituents of grits removed in the three WWTPs (type of material, water content, and density).
5- Determine the disposal ways of screenings and grits in the three WWTP (new neglected solid waste)

1.4 Significance

The quantitative and qualitative data about screenings and grits removed in the main WWTPs in the West Bank are of vital importance for proper management of these wastes. These data are not only important for Palestine but also for other countries with similar demographic, geographic and climatological features and poor infrastructure, e.g. poor solid waste management especially in the developing countries.

1.5 Scope of the study

The scope of this study is three wastewater treatment plants in the west Banke/ Palestine, namely Al-Tira, Al-Bireh, and Jericho WWTPs.

Chapter two

Literature review

2.1 Screening

2.1.1 Classify of screening unit

The first unit operation used at WWTP is “Screening”. The screen equipment consists of parallel bars usually ranging from large to middle size openings or a perforated plates with different geometry and size openings. The material removed by these devices are known as screenings. The most specific classify of screening units is gap size of screens used that ranges from a few cm to mm and sometime less than 1 mm when a plant use membrane bio reactors. Table 1 presents the gap sizes of screens used and sieving operations on the base of used treatment process used in the WWTP.

Table 1| Screens and sieves classification based on gap size and associated treatment process (Frechen*et al*., 2006)

Screen or sieve type	Gap size	Treatment of wastewater process
Coarse screen	60 mm through 20 mm	Activated sludge
Middle screen	20 mm through 10 mm	
Fine screen	10 mm through 2 mm	Biofiltre
Coarse sieve	>1 mm	Membrane bioreactor
Fine sieve	<1 mm	technology (MBR)
Micro sieve	<0.05 mm	

Most large WWTPs use mechanically cleaned screens to remove large material because they reduce time, labor costs, improve flow condition and increase efficiency of removal material, but need equipment maintenance. Manually cleaned screens require little or no equipment maintenance and provide a good alternative for smaller plants, but need labor and more time (EPA,2003; Frechen*et al*., 2006).

2.1.2 Important of screening units

The main task of screening equipment, as part of the preliminary treatment, is to protect all mechanical parts of the WWTP from damage by removing large objects from raw wastewater because large objects can damage or clog pumps and pipes, and can block valves and hang over weirs. So, screens reduce operation and maintenance problems in the WWTPs (Metcalf and Eddy/Aecom, 2014).

2.1.3 Quantity of screenings

A few studies were carried out in the screening. The regional observatory of waste in the Region Ile -de-France (Ordif, 1999) issued a general report about the management of waste generation in WWTPs, including screenings. Another study by Clay (1996) reported an investigation concerning the development of disposal strategies of screenings at minimal costs. The Clay (1996) reported the wastewater interred a plant about 1.9 million cubic meters daily, generating yearly 46,000 m^3 of screenings, which means 0.0242 m^3 screens per m^3 waste. These studies reported data relative to the volumes of screenings generated, their composition and existing treatment method, but they were carried out more than 20 years ago. Since then, consumer habits, wastewater collection system and treatment technologies have changed and screening composition completely changed therefor the data need to be updated.

The amount of material remove from the screening stage varies from plant to plant because change of many factors in each plant such as type of sewer, gap size of screens, weather and type of waste. In France three plants were studied by LeHyaric (2009) who collected a total 30 samples from three WWTP namely Annemasse, Bourg-en-Bresse andGivors. The overall mass collected in the three WWTP by different screens is summarizing in Tables 2 and 3.

Table 2 | Quantity of waste generated at Givors plant from each open size of screening stage in France (LeHyaric, 2009).

	Givors1 (May 2007)				Givors2 (Sep 2007)			
	Wet mass		Dry mass		Wet mass		Dry mass	
Gap size	Kg	Kg/(c.y)	kg	Kg/(c.y)	Kg	Kg/(c.y)	kg	Kg/(c.y)
60 mm	352.3	0.28	147.9	0.12	330.5	0.27	145.9	0.12
6 mm	316.1	0.25	117.9	0.09	367.6	0.29	102.3	0.08
total	668.4	0.53	265.8	0.21	698.1	0.56	248.2	0.2

Table 3| Quantity of waste generated from each open size of screening stage in Bourg-en-Bresse and Annemasse in France (LeHyaric, 2009).

	Bourg-en-Bresse(Nov 2007)				Annemasse (Jan 2007)			
	Wet mass		Dry mass		Wet mass		Dry mass	
Gap size	Kg	Kg/(c.y)	kg	Kg/(c.y)	Kg	Kg/(c.y)	kg	Kg/(c.y)
60 mm	-	-	-	-	372.7	0.97	61.5	0.16
15 mm	483.7	0.98	77.1	0.16	588.2	1.53	74.9	0.2
3mm	423.3	0.86	65.3	0.13	380.6	0.99	56.5	0.15
Total	907	1.84	142.3	0.29	1341.5	3.5	192.5	0.51

According to the author, the difference in results is due to several reasons. Firstly, the waste generation has relationship with the gap size of the screens whereas Givors has two gap sizes 60 and 6 mm but Bourg-en-BresseandAnnemasse used three gap size 60, 15 and 3 mm. Secondly, weather variation whereas Bourg-en-Bresseand Annemasse numbers are greater than the first, and this is because the samples were taken in the winter season. The effect of rainfall on waste production should be taken into account especially in the combined sewers system.

In Portugal, a PhD Thesis by Varela (1959) studied the quantity of screenings by collecting the available data (weight, population, annual per capita production, flow) from 13 areas in Portugal in five years, and the results shown in Table 4.

Table 4| Quantity of screenings waste production in five year in Portugal (Varela, 1959)

year	Wight ton	population	Kg/c.y	Flow m^3
2009	3300	2,900,000	1.379	230,000,000
2010	5000	5,250,000	.952	410,000,000
2011	6050	5,750,000	1.052	430,000,000
2012	6000	5,700,000	1.052	400,000,000
2013	5700	5,900,000	.9661	440,000,000

Simtejo in Portugal contain three WWTPs namely Alcântara, Beirolas and Chelas, the Varela (1959) studied these plant and reported the daily production of screenings per capita for 7 years. The results are shown in Table 5.

Table 5| Daily production of screens per capita on three WWTP in Portugal Varela (1959).

year	Alcântara (screenings per capita (g/c.d))	Beirolas (screenings per capita (g/c.d))	Chelas (screenings per capita (g/c.d))
2007	3.3	4.5	4.8
2008	5.5	3.1	4.2
2009	3.1	2.3	2.5
2010	3.5	3.1	2.4
2011	2.8	2.7	2.2
2012	3	3.4	2.9
2013	2	2.1	3

In Ireland, the Environmental Protection Agency (1995) reported the quantity of screenings is difficult to estimate as there is no data available for wastewater treatment plants in Ireland.

2.1.4 Types and quality of screenings

Raw screenings have high percentage of water content larger than 80%, 20% solid fraction. The part of solid mainly contains cellulose more than 80% and plastic between 2-14 % and mineral compound. Cellulose often drives from toilet paper, trees branches and other hygiene articles. Plastic mainly come from protective foils, packaging and cotton sticks. Feces, food residues, besides, natural material such as grass clipping and leaves can be found (Hanben, 1999).

Mineral compounds such as sand, grit and stones have percentage of 3.5-9.5%, this in separate system but in a combined system higher percentages are found (Hanben, 1999). When analyzed screenings, finds other constituents that have small percent like condoms, hair, crow, toys, caps, medical dipsticks, bottle caps from liquid soap, articles of clothes, cigarette ends, cleaning wipes, lighters, glasses, stationary, razor blades, sets of teeth were found that means can find anything(Kuhn and Gregor, 2013).

LeHyaric (2009) characterized the screenings samples collected from three WWTP in France. The characterization aimed to sort the type of screenings waste to give better option for disposal. All samples of screenings (gap size 6 mm) and more were analyzed by hand for the materials type they contained. The first step was weighing the whole samples (wet mass), and the volumes were measured for the calculation of the volumetric mass. Afterwards, the samples were dried in an oven at a temperature of 80 ºC. After weighing the dry samples, they were sorted manually into ten components of materials (see Table 6). Next, the fractions were weighed separately to calculate their mass fractions on dry matter basis. Table 7 presents the material fractions and their percentages on dry matter basis in each screenings sample (gap size 6mm).

Table 6 | Classification of material to categories to be considered for the characterization of screenings in France (LeHyaric, 2009).

Screenings fractions	Fraction components
Sanitary textiles	Tampons, wipes, sanitary towels,
Fine fraction (0.20 mm)	Sand,ash, vegetal waste, broken glass, and fine residues that pass the sieve
Vegetal	Twigs, Cut grass, leaves, herbs, flowers, branch,
Papers, cardboards	Packages, paper rolls, newspapers, brown corrugated cardboard.
Plastics	Plastic containers, pipes, plastic bags, plastic films, pens, toothbrushes
Textiles	Natural fiber textiles (cotton, wool, linen…) and synthetic fibre textiles
Metal, Aluminium	Cans, keys, tools and all ferrous and non-ferrous materials
Composites	Packaging made of several materials (paper, plastic, aluminium)
Combustible	Leather (shoes, bags…), rubber, crates, boxes, wood (planks…),
Incombustible	Inert materials not included in other categories, glass and minerals

Table 7 | Percentages of each category of material (% of dry mass) in screenings of three WWTP in France (LeHyaric, 2009).

Fractions	Plant 1	Plant 2	Plant 3
Sanitary textiles	74.7	76.1	67.7
Fine fraction (0.20 mm)	15.2	13	15.2
Vegetal	4.4	1.9	0.2
Papers, cardboards	1.8	4.7	13.1
Plastics	2.6	2	1.1
Textiles	0.4	0.7	.02
Metal, Aluminium	0.4	0.1	0
Composites	0.2	0.4	0.2
Combustible	0.3	1	2
Incombustible	0.1	0.1	0.3
total	100	100	100

For the three studied plants, high proportion of sanitary textiles with percentage more than 67% was noticed. The reasons for this high fraction might be due to firstly increasing use of disposable wipes (for cleaning surfaces or body care) and secondly poor awareness of the consumers who often through their sanitary textiles into the toilets while they have to dispose them with the household solid waste. In another study in Ireland, the Environmental Protection Agency (1995) provide an indicative range that it density of screening is 600 - 950 kg/m3 and water percent 70% - 90%.

2.2 Grit removal chamber

2.2.1 Types of grit removal chamber

There are many types of grit removal chambers including aerated grit chamber, detritus tanks (storm term sedimentation basins), Vortex type (paddle or jet include vortex), Hydrocyclones (cyclonic inertial separation) and Horizontal Flow Grit Chamber (velocity controlled channel). When selecting grit removal process many factors must be taken like potential adverse effects on downstream processes, organic content, removal efficiency, cost and finally quantity and characteristics of grit. These will be taken in this thesis, (EPA,2003; Wastewater Technology Fact Sheet,2003).

2.2.2 Important of grit removal chamber

There are many important objective for the Grit Removal Chambers in the WWTP which are to protect moving mechanical equipment from abrasion and abnormal wear and to reduce maintenance cost in the frequency of digester cleaning caused by excessive accumulation of grit and to prevent heavy deposits in pipelines and channels.

2.2.3 Quantity of grits

The recent studies about grit quantities are almost nonexistent. In addition screenings, the PhD thesis of Varela, E. S(1959) studies the quantities of grits by collecting the available data (Wight, population, annual per capita production, flow) from 13 area in Portugal in five year and the results shown in Table (8). They also study studied the Simtejo region in Portugal that contains three WWTP namely (Alcântara, Beirolas and Chelas), study this plant and give the daily production of screens per capita for 7 years, the results shown in Table (9) Varela(1959).

Table 8| Quantity of grit production in five year in Portugal (Varela, 1959)

year	Wight ton	population	Kg/c.y	Flow (m^3)
2009	3900	2,900,000	1.344	230,000,000
2010	9000	5,250,000	1.714	410,000,000
2011	8200	5,750,000	1.426	430,000,000
2012	7800	5,700,000	1.368	400,000,000
2013	7800	5,900,000	1.322	440,000,000

Table 9| Daily production of grit per capita on three WWTP in Portugal (Varela, 1959)

year	Alcântara (grits per capita (g/c.d))	Beirolas (grits per capita (g/c.d))	Chelas (grits per capita (g/c.d))
2007	3.6	3.7	9.5
2008	1.8	8.6	12
2009	3.2	8.8	7.5
2010	9	7.2	10.1
2011	6.8	4	7
2012	5.3	3.4	5.4
2013	4.5	3.4	7.2

2.2.4 Types and quality of grits

As mention earlier, constituents in wastewater like sand, cinder, gravel, shattered glass and similar substances of settling velocity significantly higher than organic matter are termed grit. All of studies reported says the same general information but no study gives specific information about the type and quality of grit, and this gives more important of this thesis. (EPA, 2003; Davis, 2010).

The EPA (1995) gave some information like range for moisture content will contained in removed grit up to 50% and listing type and source of grit:-

1- Domestic waste like: glass, coffee grounds, seeds, eggshells.
2- Industrial effluent like: metals, sands, clays.
3- Storm water drains like: sands, pebble, and road making materials.
4- New construction sites like: sand, gravel, concrete, blocks, and stone.
5- Infiltration like: leaching of soil fines into the pipe.

The transport of these items within the sewer system depends on the type of sewer system if combined or separate and the condition of sewer in terms of leakages, and gradient of the sewers.

2.3 Disposal of screenings and grits

The screening, grit and sludge are classified as a waste under the European list of waste and National legislation the Ordinance 209/2004 with the code 19 08 01, 19 08 02 and 19 08 05 respectively (Varela, 1959; EC, 2000).

Usually, special attention is given to sludge treatment and final disposal, but screenings and grit are neglected due to the relatively small amounts that are produced (Sidwick,1991; Le Hyaric*et al.*, 2009; Cadavid-Rodríguez, 2013), but also because there is no specific legislation for this type of wastes.

Increasing production of screenings and grits is expected because of population and flow increase, as well as developed technologies in WWTP. The most common method used to the disposal of screenings and grits is landfill and incineration but this depending on availabilities of landfills or incinerators in local community. Since the incinerators of sludge are able to burn only small amount of screenings, most of the screenings are disposed in landfills (Clay *et al.*, 1996).

Land filling however is not favored by the European waste regulations (Council directive 1999/31/EC on wasteland filling). Moreover, land filling is not permitted for waste with high water content of more than 70% w/w (Huber *et al*., 1995; Clay *et al*., 1996). Incineration is good alternative but when contain higher water content is un favorite (Bode &Imhoff, 1996). When now the quantity and quality of screenings and grits can decide the best way of disposal and decide the suitable treatment method other than land filling or incineration may therefore prove to be more appropriate for screenings and grit (Le Hyaric*et al.*, 2009).

Chapter three

Methodology

The study objectives were achieved by the means of data collection from three main selected WWTP in the West Bank. Available data of screenings and grits quantity and quality from these WWTPs were collected and analyzed, while missing data were measured in situ and in the lab.

When selection the WWTP many Criteria it was taken :-

- Natural of waste water if municipal waste or industrial waste
- Size of plant : number of people served, number of waste water cubic inter plant
- Types of waste collection :separate or combine system
- The gap size of screens used
- Types of grit removal used
- Number of upstream pumps

3.1 Study area

The study area included three locations. The first is Ramallah city where Al-Tira WWTP exist, the second is Al-Bireh where Al-Bireh WWTP exist, the third is Jericho city where Jericho WWTP exist. All of these cities are located in West Bank Palestine. Two cities Al-Bireh and Ramallah have same natural term in topography and climate but different with Jericho and they are considered as the main Middle West Bank cities of the occupied Palestinian Territories.
The following sections introduce and summarize the locations, areas serviced, climate, capacity and Technology of WWTP for each of the three plants.

3.1.1 Al-Tira WWTP

3.1.1.1 Location and area serviced of Al-Tira WWTP

Al-Tira WWTP is located in the southwest of Ramallah and Al-Bireh governorate in the West Bank, specifically in the Al-Tira neighborhood, at an altitude of 603 meters above sea level. It is classified as a rocky mountainous area. The area serviced from Al-Tira WWTP is Al-Tira and diplomat neighborhood all of this located in Ramallah city. The area is classified as residential no industrial in this area (Ramallah municipal 2021). Figure 1 shows the location of Al-Tira WWTP relation to the West Bank.

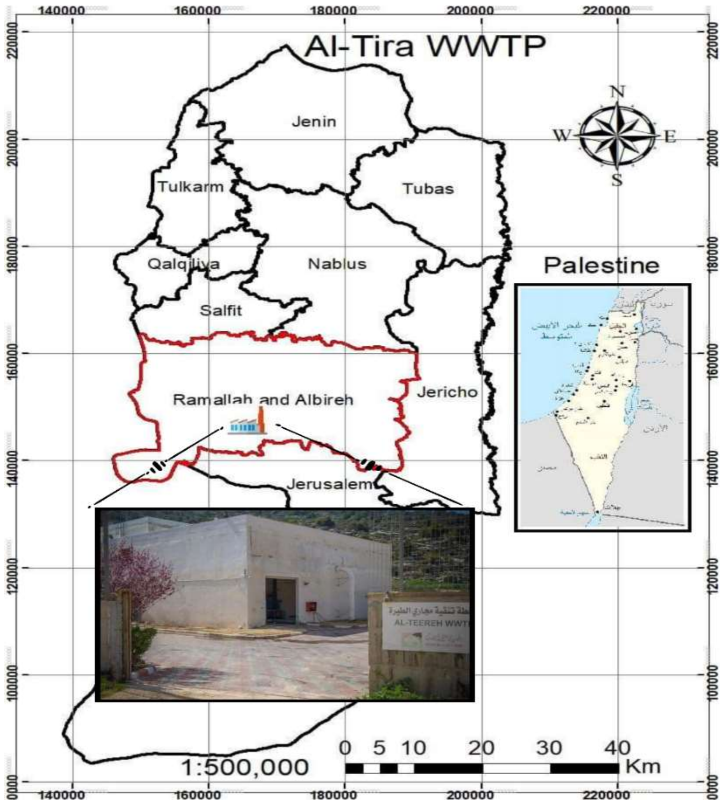

Figure 1| Location of Al-Tira WWTP (prepared by M. Falana).

3.1.1. 2 Climate of Al-Tira WWTP

The area served is part of Ramallah city so its climate is that of Ramallah. Ramallah have Mediterranean climate prevailing. The average rainfall is about 500 millimeters per year and it snows sometime. In general, the average temperature in winter rarely reaches 0°C, and in summer it rarely exceeds 35°C, so it can be said that the average annual temperature ranges between 5-25°C (Ramallah municipality, 2021).

3.1.1.3 Capacity of Al-Tira WWTP

The area served has developed at high rate and continue where many new commercial centers and housing projects are constructed that encourages investors to start new business. The amount of flow enter Al-Tira WWTP is around 2500 m^3per day and the number of people served is about

25000 people as reported by Ramallah municipality and these numbers are continuing to increase (Ramallah municipality, 2021).

3.1.1.4 Technology of Al-Tira WWTP

Al-Tira WWTP has two stages, in preliminary namely screens and grit removal but according to the operator of plant the quantity of material removed from grit removal chamber in Al-Tira WWTP is very small, no more than 1 liter in three or four months and that makes the municipality put manholes deeply 3 meter in waste water line before water inter the plant. Table (10) illustrates all information and technology about screens, grit removal champers, technology of treatment, number of upstream pumps, type of sewer and type of waste (Ramallah municipality, 2021).

Table 10| Information and technology in Al-Tira plant

Types of sewer	Separate
Open size of screen	50mm, 6mm, 2mm
Clean of screen	50mm manual 6mm mechanical with timer 2mm mechanical with timer
Types of grit removal chamber	Vortex with screw
Clean of grit removal chamber	mechanical
Technology of treatment	MBR
Number upstream pumps	0
Types of waste water	Domestic

3.1.2 Jericho WWTP

3.1.2.1 Location and area served of Jericho WWTP

Jericho WWTP is located in the south of Jericho -West Bank at an altitude of -316 meter from sea level so it is the lowest WWTP in the world. The area serves by Jericho WWTP is Jericho city and Aqbet Jabber refugee camp. The area land use and activities included residential, agricultural and tourism. Jericho is famous for its citrus fruits, dates, bananas, flowers and winter vegetables. Because Jericho is the oldest and lowest city in the world, it has great tourist destination. The area served is classified as desert sandy region (Jericho Municipality, 2021). Figure 2 shows the location of Jericho WWTP.

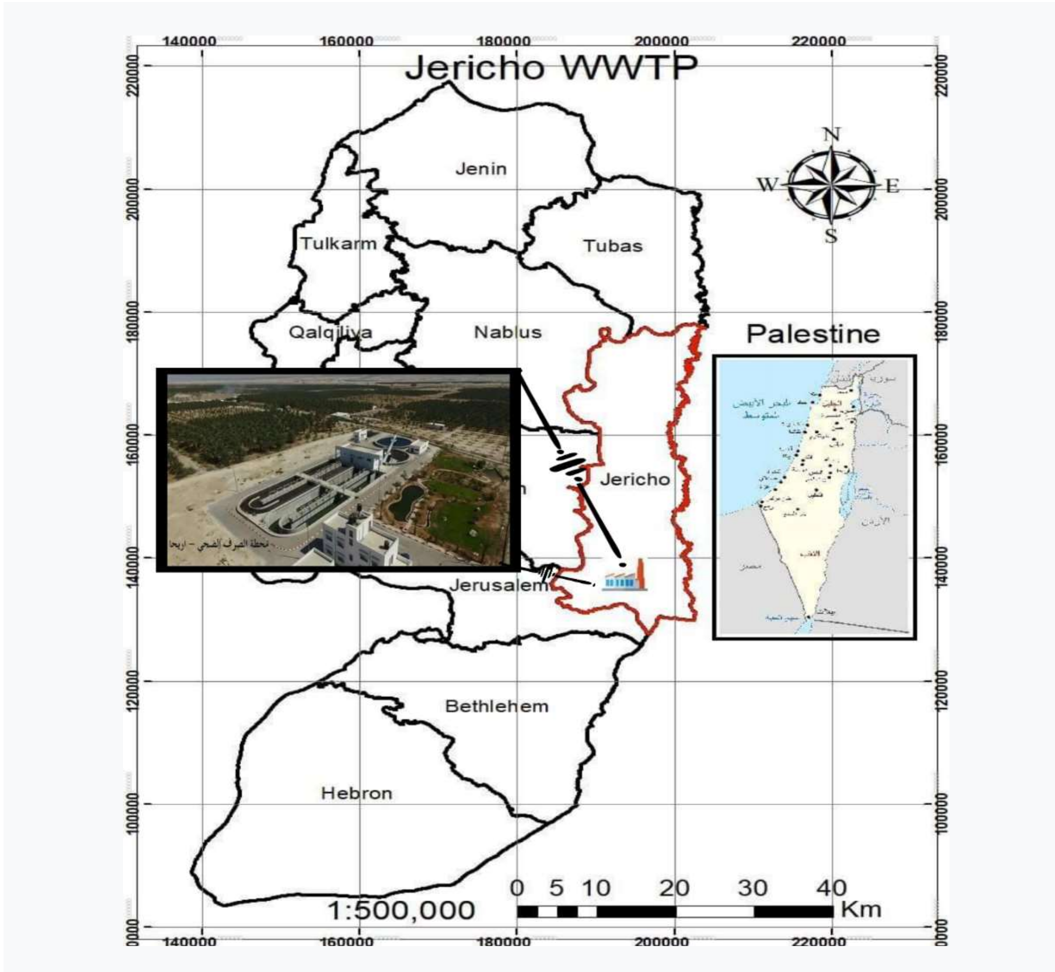

Figure 2| Location of Jericho plant (prepared by M. Falana).

3.1.2.2 Climate of Jericho WWTP

The climate of Jericho is a tropical, with very high temperature and complete drought in summer and a warm winter and little rain. The average summer temperatures reaches 44 ºC, falling in winter to less than four degrees. The winter precipitation falls at a rate of 150 mm per year and humidity of 50% (Jericho Municipality, 2021).

3.1.2.3 Capacity of Jericho WWTP

The amount of flow enter Jericho WWTP is around 2400 m^3 and this number increase continuously because it’s a new plant and connection to the sewers network increases day by day. The number of people served is unknown to Jericho municipality because Jericho city contain travel point, security camps, active tourist movement and active villas construction. All of this makes it difficult to know the exact number of people who are connected to the sewers network. But knowing the wastewater flow entering the plant and assuming a per capita water consumption of 120 l/d and 0.8 of 120 l/d goes to the sewers network, then the wastewater production per capita is 96 l/d. With dividing 2400 m^3over 96 l/d results in 25,000 person which is the estimated number of connected people (Jericho Municipality, 2021).

3.1.2.4 Technology of Jericho WWTP

The Jericho WWTP has three stages in preliminary namely screens, grit removal and scum removal. The stage of scum removal after grit removal, the function of scum removal is removing all of float material. Table 11 illustrates the type of sewer, open size of screens; clean of screens, type of grit removal, technology of treatment number of upstream pump and types of waste (Jericho Municipality, 2021).

Table 11| Information and technology in Jericho plant

Types of sewer	Separate
Open size of screen	50mm, 5mm
Clean of screen	50mm manual 5mm mechanical with timer
Types of grit removal chamber	Vortex
Clean of grit removal chamber	Mechanical
Technology of treatment	Activated sludge
Number up stream pumps	3
Types of waste	Domestic

3.1.3 Al-Bireh WWTP

3.1.3.1 Location and area served of Al-Bireh WWTP.

Al-Bireh plant is located in the south east of the Ramallah and Al-Bireh governorate West Bank, specifically at Jabal Al Taweel neighborhood at an altitude of 726 meters above sea level. The area served is the whole city of Al-Bireh with all neighborhoods and a small part of Ramallah City. The activity in Al-Bireh is residential, commercial and some industrial. Al-Bireh is a rocky mountainous area (Al-Bireh Municipality, 2021). Figure 3 shows the location of Al-Bireh WWTP in relation to the West Bank.

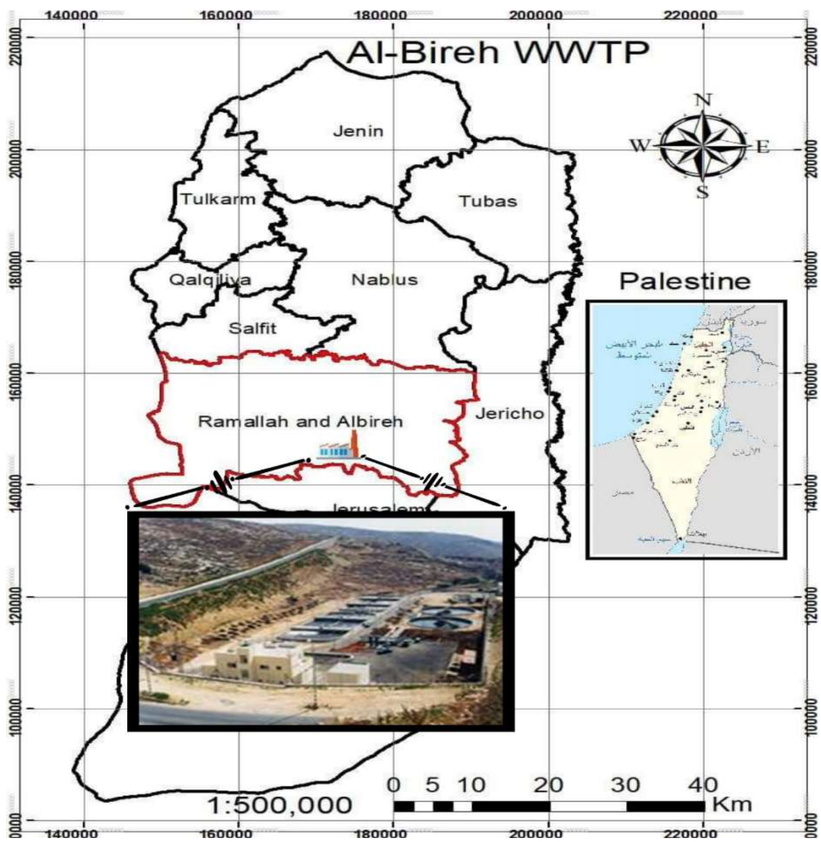

Figure 3 | Location of Al-Bireh plant (prepared by M. Falana).

3.1.3.2 Climate of Al-Bireh WWTP.

Al-Bireh like Ramallah climate has the Mediterranean climate prevailing. The average rainfall is about 500 millimeters per year. The average temperature in winter rarely reaches 0 °C, and in summer it rarely exceeds 35 °C. The average annual temperature ranges between 5-25 °C (Al-Bireh Municipality, 2021).

3.1.3.3 Capacity of Al-Bireh WWTP.

The amount of flow entered Al-Bireh WWTP is around 6000 m^3/ day in summer,10,000 m^3/d in winter reported by Al Bireh Municipality. The population of Al-Bireh is 90,000 and the percentage of connection is 93%, so the number of people served about is 83,700 as reported by Al-Bireh Municipality (Al-Bireh Municipality, 2021).

3.1.3.4 Technology of Al-Bireh WWTP.

Al-Bireh WWTP has two stage is in preliminary treatment namely screens and grit removal. Table 12 shows the type of sewer, open size of screens, clean of screens, type of grit removal, technology of treatment number of upstream pump and types of waste Al-Bireh Municipality (2021).

Table 12| Information and technology in Al-Bireh plant

Types of sewer	Separate
Open size of screen	50 mm, 20mm
Clean of screen	50mm Mechanical without timer 20mm mechanical with timer
Types of grit removal chamber	Air blower +screw
Clean of grit removal chamber	Mechanical
Technology of treatment	Activated sludge
Number up stream pumps	5
Types of waste	10% industrial , 90% domestic

3.2 Interview and existing data collections

The chief operators of the three WWTP were interviewed to obtain data about screenings and grits quantities, quality, disposal, problems, seasonal variation, etc. The existing data, if available, was collected and analyzed.

A technical visit for each plant was organized before starting to take samples in order to avoid technical problems, reducing risks, and elaborate adapted sampling strategies in collaboration with the technical staff of the plants. Employees of each plant were informed in details about the thesis program and the methodology of data collection.

3.3 Experimental work

The experimental work was divided into three parts as follow:

Part one: volume

The quantity of material removed by screens and grit removal chambers were determined for each open size of screens and grit removal during a set period time for two months between August to October. The volume of containers in each WWTP where screenings and grits are collected we determined. Measured started when a containers are empted and wait until it's full, that's when a container doesn't need a lot of time to full. When a container needs a lot of time to be full, the height of waste in the container who measured and the volume was calculated. At least three readings were be taken from each size of screens and grit removal and take the average between readings and calculate the standard deviation for average readings in three WWTP. Table 13 illustrates the number of reading from each size of screens and grit removal in three WWTP.

Table 13| number of reading from each size of screens and grit removal in three WWTP.

	Screens 50mm	Screens 20mm	Screens 6mm	Screens 5mm	Screens 2mm	Grit removal	Scum removal
Al-Bireh	3	3	-	-	-	4	-
Al-Tira	5	-	4	-	5	-	-
Jericho	4	-	-	4	-	4	4

Part two: Quality

1- Number and size of sample

Three samples were collected from each size of screens and grit in three WWTP, number of screening sample depend on number of size screens, so the total number of samples collected from the three WWTPS were 30 samples (12 samples in Jericho, 9 samples in Al-Bireh, 9 samples in Al-Tira). Each sample was collected from material produced during a set period time for two months between August to October at the same time of quantity measurement. The size of this sample will be 1 liter for grit and 1 liter for screenings, and will be composed at least three sub-samples. Table 14 illustrates the number of samples taken from each size of screens and grit removal in three WWTP.

Table 14| Number of samples taken from each size of screens and grit removal in three WWTP.

	Screens 50mm	Screens 20mm	Screens 60mm	Screens 5mm	Screens 2mm	Grit removal	Scum removal
Al-Bireh	3	3	-	-	-	3	-
Al-Tira	3	-	3	-	3	-	-
Jericho	3	-	-	3	-	3	3

2- Procedure of analyses screenings and grits sample and description

After collections the samples from WWTP this sample are taken to laboratory and weighted before drying in the oven, after drying weight the sample and start hand separation on screen sample where each type of material is separated and weighted. In grit sample and screen 2mm cannot use hand separation but can use sieve analyses and weight the material remain at each open size of sieve and description the type of material.

Part three: Calculation

The calculation divided in three sections, section one volume calculation through it as mention above calculate the size of container to determine the size of material remove and connection the size with time and number of people served and determent waste production as function of gap size of screen and grit to calculate:-

1- Daily production volume (L/d).
2- Daily production dry mass (Kg/d).
3- Daily production wet mass (Kg/d).
4- Annual production volume per capita (L/c/y).
5- Annual production dry mass per capita (kg/c/y).
6- Annual production wet mass per capita (kg/c/y).
7- Volume production per cubic meter (L/m^3).
8- Dry mass production per cubic meter (Kg/m^3).
9- Wet mass production per cubic meter (Kg/m^3).

Section two, quality calculation as mention the size of sample known and the sample weighted before dry and after dry through it can calculate:-

1. Percent of water

$$w_{\%} = \frac{m_w - m_d}{m_w}$$

2. Percent of solid

$$s_{\%} = \frac{m_d}{m_w}$$

3. Moisture content (m)

$$m_{\%} = \frac{m_w - m_d}{m_d}$$

4. Wet density

$$\rho = \frac{m_w}{v}$$

5. Dry density

$$\rho_d = \frac{\rho}{1 + m_{\%}}$$

$w_{\%}$: water percent
m_w: wet mass
m_d: dry mass
$s_{\%}$: percent of solid
ρ : total unit Wight (density)
ρ_d : dry unit wight (dry density)
$m_{\%}$: moisture content

source: (OZA, 1969)

Section three: check calculation that's through calculate the standard deviation for all reading and result by equation of standard deviation or excel sheets

$$\sigma = \sqrt{\sum_{n=1}^{\infty} \left(\frac{(\mathrm{x} - \mathrm{mean})^2}{\mathrm{n} - 1} \right)}$$

σ: Standard deviation
x: Value of reading
$mean$: Average of reading
n: Number of reading

Chapter four

Results and discussion

4.1 Quantity of screenings and grits

It was found that the per capita generation of screenings and grits in the three WWTP had never been calculated. The screenings and grits waste production from the three studied WWTP were calculated by determining the produced volume in WWTP in each size as explained in methodology and calculated the mass production per capita per year. The following sections introduce and summarize the quantity of screenings and grits production from three WWTP. Annex (1) illustrates reading the quantity at time intervals for each size of screens and grit in three WWTP with standard deviation for each reading and average. Table 15 illustrates number of reading from each size of screens and grit removal in three WWTP and the average and standard deviation for each reading.

Table 15 |number of reading from each size of screens and grit removal in three WWTP and the average of liter per day generation and standard deviation for this reading.

	Screens 50mm	Screens 20mm	Screens 6mm	Screens 5mm	Screens 2mm	Grit removal	Scum removal
Al-Bireh	3	3	-	-	-	4	-
Avg(l/d)/ ***σ***	26.55/1.38	28.4/1.47				724.7/3.75	
Al-Tira	5	-	4	-	5	-	-
Avg(l/d)/ ***σ***	6.58/0.55		17.44/0.58		117.58/2.5		
Jericho	4	-	-	4	-	4	4
Avg(l/d)/ ***σ***	28.42/3			29.7/2.29		130.9/3.28	16.1/2.5

The flowing table (16), (17), (18), (19), (20) and (21) represented all results that relate to quantity value in three WWTP.

Table 16| Solids generation from each screenings stage and grit in Al-Bireh WWTP

	Liter per day L/d	Kilogram per day Kg / d (dry)	Kilogram per day Kg / d (wet)	Liter per capita per year L/c/y	Kilogram per capita per year Kg/c/y(dry)	Kilogram per capita per year Kg/c/y(wet)
Screen 50mm	26.55	3.48	21	0.11	0.0149	0.09
Screen 20 mm	28.4	3.39	20.89	0.12	0.0145	0.09
Grit removal	724.7	171.8	586.6	3.11	0.75	2.52
sum	779.65	178.67	628.49	3.34	0.78	2.7

Table 17| Volume and mass waste generation per cubic meter wastewater in Al-Bireh WWTP

	Waste / waste water L/m^3	Wet Mass/waste water G/m^3	Dry Mass/waste water G/m^3
Screen 50 mm	0.00442	3.5	0.58
Screen 20 mm	0.00473	3.48	0.565
Grit removal	0.12	97.76	28.63
sum	0.1291	104.74	29.775

Table 18| Masses of waste and capita per year generation from each screenings stage and grit in Al-Tira WWTP

	Liter per day L/d	Kilogram per day Kg / d (dry)	Kilogram per day Kg / d (wet)	Liter per capita per year L/c/y	Kilogram per capita per year Kg/c/y(dry)	Kilogram per capita per year Kg/c/y(wet)
Screen 50 mm	6.58	0.8	4.2	0.096	0.011	0.061
Screen 6 mm	17.44	3.41	8.39	0.25	0.05	0.122
Screen 2 mm	117.58	15.4	72.8	1.71	0.22	1.06
sum	141.6	19.61	85.39	2.056	0.281	1.243

Table 19| Volume and mass waste generation per cubic meter wastewater in Al-Tira WWTP

	Waste / waste water L/m^3	Wet Mass/waste water G/m^3	Dry Mass/waste water G/m^3
Screen 50 mm	0.0026	1.68	0.32
Screen 6 mm	0.0069	3.356	1.364
Screen 2 mm	0.047	29.12	6.16
sum	0.056	34.36	7.844

Table 20| Masses of waste and capita per year generation from each screenings stage and grit in Jericho WWTP

	Liter per day L/d	Kilogram per day Kg / d (dry)	Kilogram per day Kg / d (wet)	Liter per capita per year l/c/y	Kilogram per capita per year Kg/c/y(dry)	Kilogram per capita per year Kg/c/y(wet)
Screen 50mm	28.42	5.49	25.6	0.4	0.079	0.369
Screen 5 mm	29.7	5.69	13.19	0.42	0.082	0.19
Grit removal	130.9	33.3	94.74	1.88	0.479	1.364
scum	16.1	2.6	7.44	0.23	0.037	0.1
	205.18	47.08	140.97	2.57	.677	2.02

Table 21| Volume and mass waste production per cubic meter wastewater in Jericho WWTP

	Waste / waste water L/m^3	Wet Mass/waste water G/m^3	Dry Mass/waste water G/m^3
Screen 50 mm	0.0118	10.66	2.28
Screen 5 mm	0.0123	5.49	2.37
Grit removal	0.054	39.47	13.875
Scum removal	0.0067	3.1	1.08
sum	.084	58.72	19.6

All results show that Al-Bireh has the highest values of all results especially in daily production of dry mass and annual production of dry mass per capita and dry mass production per cubic meter flowing, Jericho then Al-Tira. That can be justified, first old of the sewer system in Al-Bireh city and this allow the soil and other waste enter the sewer system, second in Al-Bireh around 10% of wastewater entered the sewer come from industrial, third fined some of the drainage holes on the streets connect to the sewer system and this holes can collect high quantity of solid waste and entering a lot of waste in the street to the network because and this lead to weak infrastructure and pore solid waste collection. The difference between Jericho and Al-Tira can explained by to size open of screen used in each plant, in Al-Tira used one stage contain three size of screen without grit removal but in Jericho used three stages, the first screening contain two size of screen, the second is grit removal, the third is scum removal and this stage can collect more waste than Al-Tira.

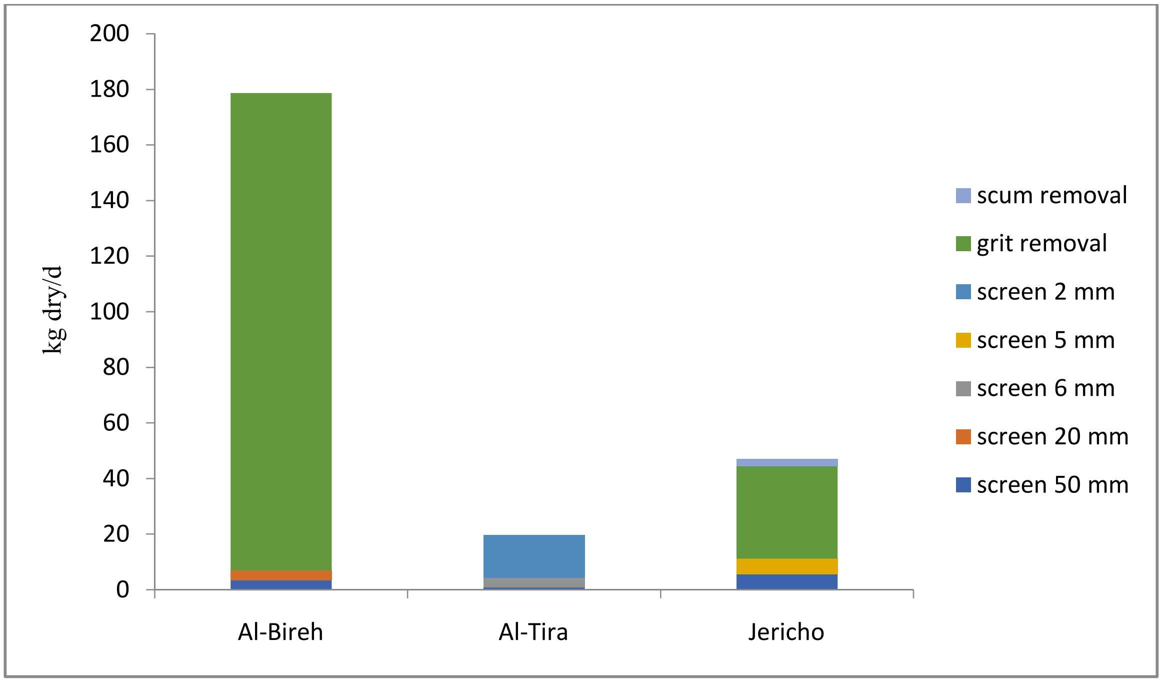

Figure 4| Dry mass per day generation from each size of screen and grit in three WWTP (kg dry/d)

Table 22| Dry mass per day generation from each size of screen and grit in three WWTP (kg dry/d).

	Screens 50mm	Screens 20mm	Screens 60mm	Screens 5mm	Screens 2mm	Grit removal	Scum removal	sum
Al-Bireh	3.48	3.39	-	-	-	171.8	-	178.67
Al-Tira	0.8	-	3.41	-	15.4	-	-	19.61
Jericho	5.49	-	-	5.69	-	33.3	2.6	47.08

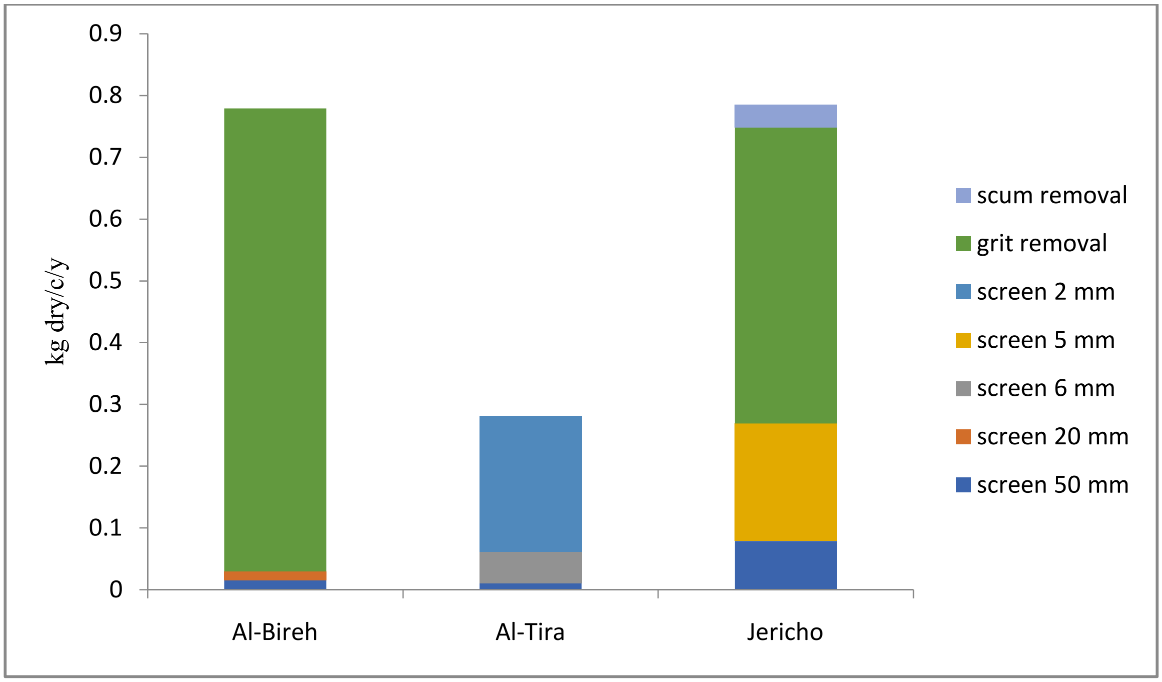

Figure 5 | Annual dry mass per capita generation from each size of screen and grit in three WWTP (kg dry/c/y)

Table 23| Annual dry mass per capita generation from each size of screen and grit in three WWTP (kg dry/c/y).

	Screens 50mm	Screens 20mm	Screens 60mm	Screens 5mm	Screens 2mm	Grit removal	Scum removal	sum
Al-Bireh	0.015	0.014	-	-	-	0.75	-	0.779
Al-Tira	0.011	-	0.05	-	0.22	-	-	0.281
Jericho	0.079	-	0	0.19	-	0.48	0.037	0.786

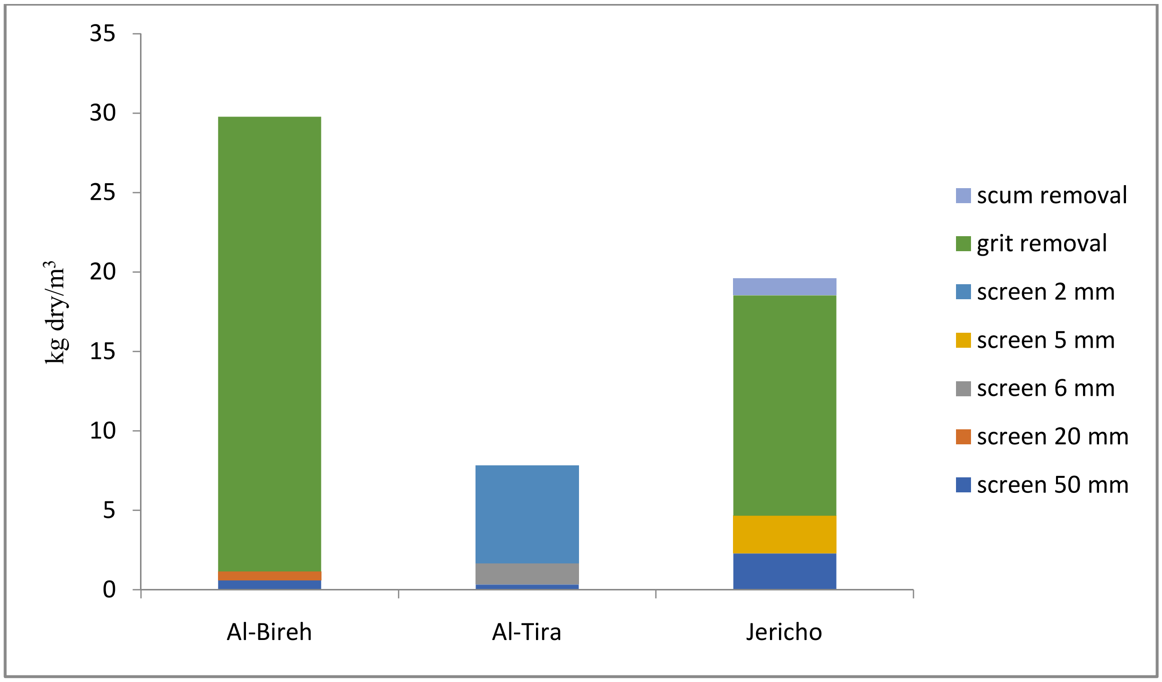

Figure 6| Dry mass waste per cubic meter generation from each size of screen and grit in three WWTP (kg dry/m^3)

Table 24| Dry mass waste per cubic meter generation from each size of screen and grit in three WWTP (kg dry/m^3).

	Screens 50mm	Screens 20mm	Screens 60mm	Screens 5mm	Screens 2mm	Grit removal	Scum removal	sum
Al-Bireh	0.58	0.565	-	-	-	28.63	-	29.77
Al-Tira	0.32	-	1.36	-	6.16	-	-	7.84
Jericho	2.28	-	-	2.37	-	13.875	1.08	19.6

In figures (4), (5) and (6) and table (22), (23) and (24) it can be noticed that the quantities of material are not the same as compared to the same size of screen which mean every plant has a specificity and each city has culture of using and disposing of materials and this has high effects to quantity of material in each size of screens and this is clear in screens 50 mm because this size exists in three WWTP. Also noticed that the quantity of material removed from grit removal between Al-Bireh and Jericho not the same and this because the size of screen, the final size of screen in Al-Bireh is 20 mm and it allow all of materials less than 20 mm to go to the grit removal but in Jericho the final size is 5 mm which means the material goes to grit removal is more in Al-Bireh as show in table (24) the sum of material removed from screens and grit removal in Al-Bireh is 29.77 kg/ m^3 and the quantity from grit removal alone is 28.63 kg/ m^3 and this represented 96% of quantity but in Jericho the sum of material removed from screens and grit removal is 19.6 kg/ m^3 and the quantity from grit removal alone is 13.875 kg/ m^3 and this represented 70% of quantity. This results confirm the important of diversity of screens size and relation to the efficiency of grit removal.

LeHyaric (2009) has many values of annual dry and wet mass per capita generation from screen in three WWTP, the wet value range between (0.53-3.5) Kg/c.y and dry value range between (0.2-0.51) Kg/c.y. Varela, E. S (1959) shows annual wet mass per capita generation from screen ranging (0.72-1.98) Kg/c.y and show annual wet mass per capita generation from grit removal ranging (1.22-3.63)

The annual wet mass per capita generation from screening is in the range of (0.18-0.56) Kg/c.y and dry results are in the range of (0.11-0.18) Kg/c.y. The annual wet mass per capita generation from grit removal ranging (1.36-2.52) Kg/c.y. The results are close to study LeHyaric (2009) and Varela, E. S (1959) although it cannot be compared accurately because each plant has different size of screen, something ranged between (50mm-2mm) and another ranged between (50mm-20mm) and another (50mm-6mm), etc. In addition if plant has grit removal or not like Al-Tira plant. Another reason Al-Bireh that has the oldest sewer system and has some of industry waste but Jericho and Al-Tira that its new sewer system and no industrials waste water big, so to make the comparison right the technology system must be the same.

4.2Quality of screening and grit in three WWTP

4.2.1 Screen 50 mm in three WWTP

5.2.1.1 Screening characteristic.

After characteristic three sample from 50 mm screening In three WWTP in laboratory the results shown in figure (7) with standard deviation, the material removed from screening 50 mm in three WWTP are the same material with different proportions, as shown in Al-Bireh contain(plastic 8.4%, Animal 1%, Tissue Paper 35%, Cloth 24%, Soil 8%, Leaves and Wood 3.75 % and other 19.5 %), in Al-Tira WWTP contain (Plastic 7.8%, Animals 1.6% , Tissue paper 39.9% Cloth 48.8 % , Soil 12% , Leaves and Wood 2% , other 8%), in Jericho WWTP contain (Plastic 7.8%, Animals 1%, Tissue paper 30.7%, Cloth 22%, Soil 19%, Leaves and Wood 1%, other 3.7%), the name “others material” it’s a mixture of paper pieces with sludge and hair and other material not recognized stuck to it some of soil. It is noticed more than 50 % of material in three WWTP is tissue paper and cloth these materials absorb water which means high percent of water, Al-Tira has high percent then Al-Bireh then Jericho from other side the high percent of soil in Jericho then Al-Tira then Al-Bireh and these ratios will have an impact on density and dry density.

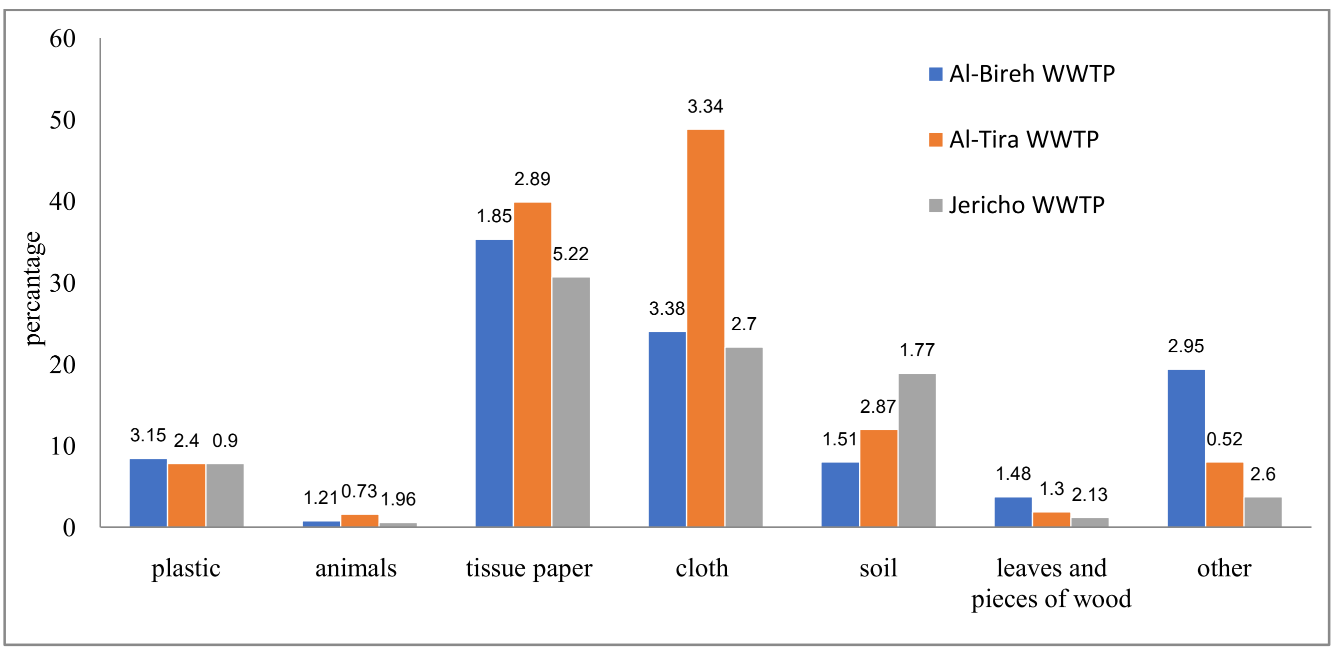

Figure 7| Percentage of characteristic screen 50 mm in three WWTP with standard deviation.

In Al-Tira WWTP, a snake has been seen in container of 50mm screening shown in figure (8) and that is dangerous for people where this snake could come out and hurt anyone.

Figure 8| Snake in screen 50 mm in Al-Tira WWTP

4.2.1.2 Percentage of water and solids.

Figure 9 presents the percent of water and solids of samples retained by 50 mm screens in three WWTP with standard deviation, as is clear more than 75% percent of sample content is water, the percent of water between three WWTP very close as show (Al-Bireh 83%, Al-Tira 81%, Jericho 78%)and percent of solid is (Al-Bireh 17%, Al-Tira19%,Jericho 22%). Back to screening characteristic find Al-Bireh and Al-Tira has high percent of tissue paper, cloth and other this material has ability to absorb water and this explains Al-Bireh and Al-Tira have percent of water more than Jericho.

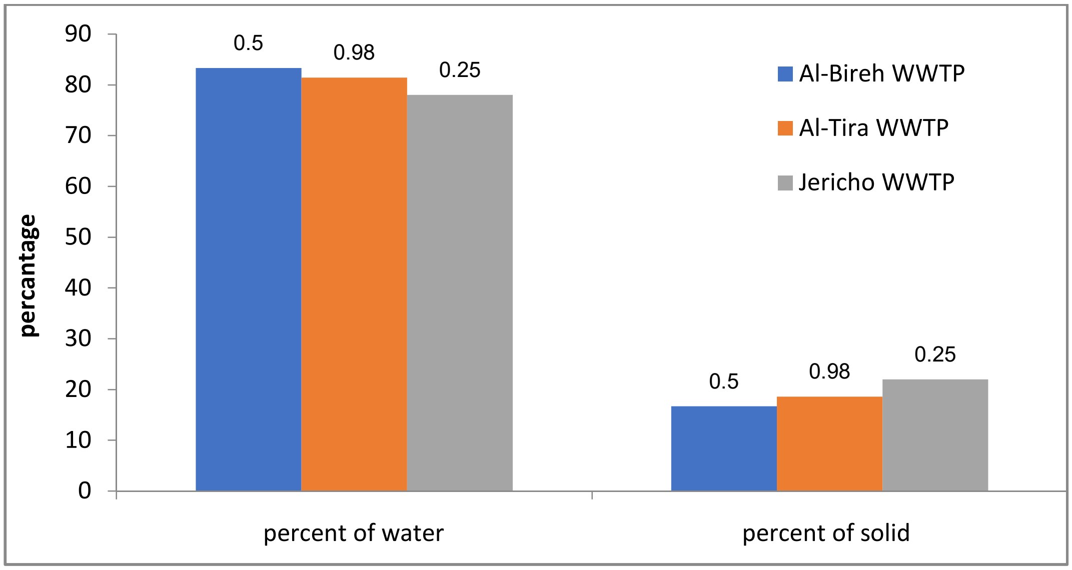

Figure 9| Percentage of water and solid of screen 50 mm in three WWTP with standard deviation

4.2.1.3 Density and dry density.

Because more than 75 % of screening is water its sure find gap between density and dry density because all of water represented more than 75 % is evaporated after put in oven, where the result of density is (Al-Bireh792 g/l, Al-Tira 638 g/l, Jericho 902 g/l) and result of dry density is (Al-Bireh 131 g/l, Al-Tira 121.7 g/l, Jericho 193.3 g/l) as show in figure (10), as noted the high density and dry density in Jericho plant and that's because contain high percent of soil and when characteristic sample find another soil he stuck of tissue paper and cloth where soil give more weight unlike tissue paper and cloth that sucks water and after dry it weights is light. The density and dry density of Al-Bireh more than Al-Tira that because the other material in Al-Bireh is more, where the other material is contain mix of paper and sludge stuck to it soil and have ability to absorb water.

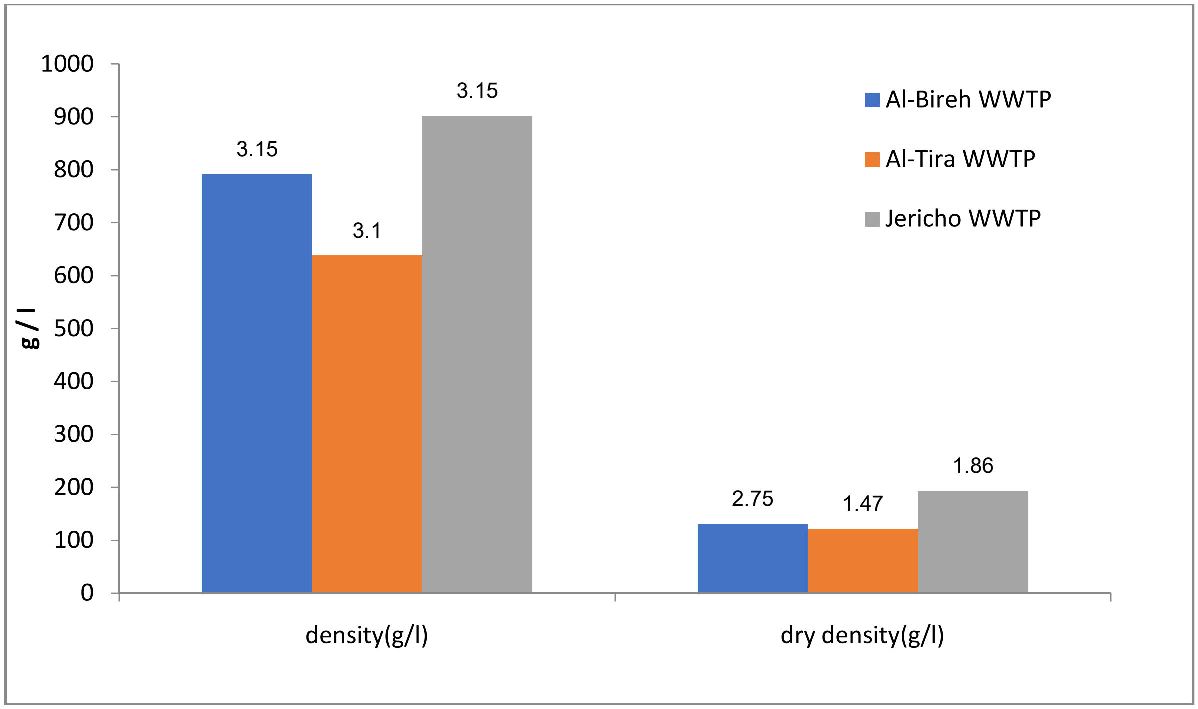

Figure 10| Density and dry density of screen 50 mm in three WWTP with standard deviation.

4.2.2 Screen 20 mm in Al-Bireh, screen 6 mm In Al-Tira and screen 5 mm in Jericho WWTP

5.2.2.1 Screening characteristic.

The characteristic three sample of screens 20mm in Al-Bireh, screens 6 mm in Al-Tira and screens 5 mm in Jericho as flowing in figure (11). in Al-Bireh the percent of material removed is (Glass 5.5%, Plastic 9.6%, Levees and Pieces of Wood 4.4%, Animal 1.7%, Vegetable 4.3%, Nuts 3%, Cigarettes 2.2%, Tissue Paper and Hair 61.2%, Soil and Small stone 8.5%, Straw 0%, others 0%), in Al-Tira (Glass 6%, Plastic 10%,Leves and Pieces of Wood 4.7%, Animal 5.2%, Vegetable 3.3%, Nuts 4%, Cigarettes 4%, Tissue Paper and Hair 29%, Soil and small Stone 10%, Straw 16.6%,others 7.4%),in Jericho (Glass 13%, Plastic 11.2%,Leves and Pieces of Wood 15.9%, Animal 11.4%, Vegetable 0%, Nuts 6.8%, Cigarettes 6.3%, Tissue Paper and Hair 0%, Soil and small Stone 10.5%, Straw 15%,others 9.8%),as notice there's similarity in material and percent between three WWTP with some different in tissue paper and hair category where Al-Bireh contain more 60%, Al-Tira 29% but in jericho 0 % and in straw category Al Bireh have 0 % but Al-Tira, Jericho have around 15%,and notice Al-Bireh has least percent in most small category except Tissue Paper and Hair have large percent, that's because different between open size of screen in three WWTP.

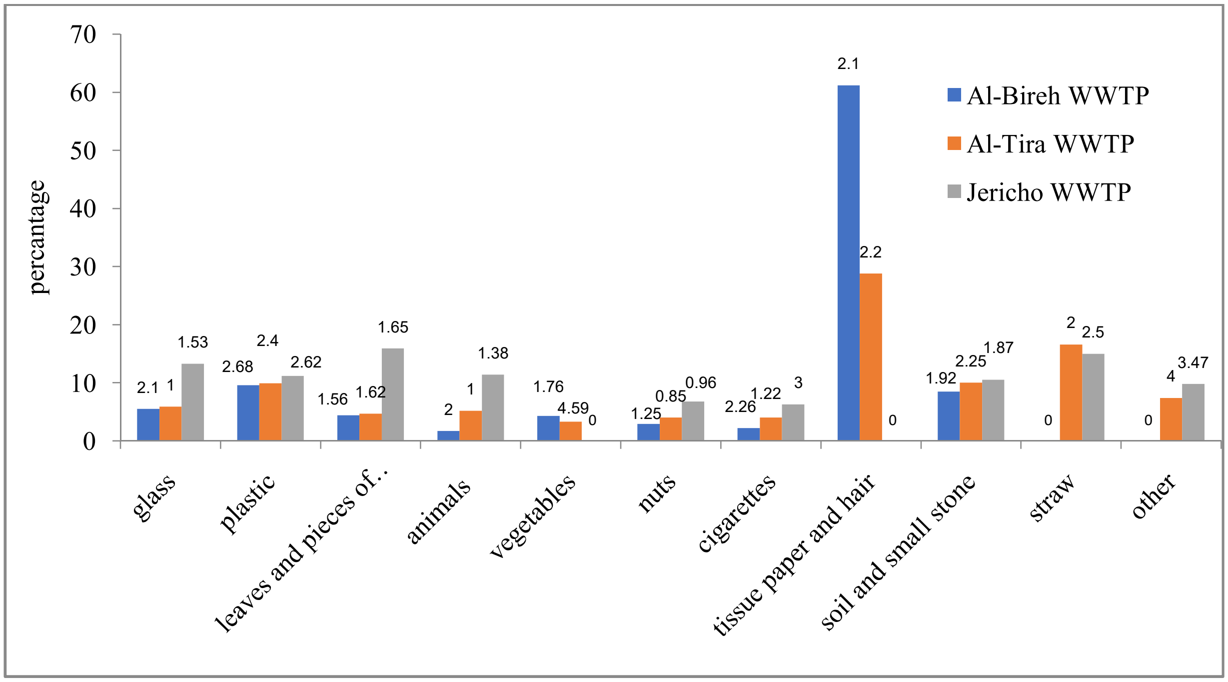

Figure 11| Percentage of characteristic screen 20 mm Al-Bireh,6 mm Al-Tira, 5 mm Jericho with standard deviation

4.2.2.2 Percentage of water and solids.

As similar screens 50 mm most of samples are water where Al-Bireh has higher percent between three WWTP by 83% followed by Al-Tira 65% then Jericho 57%. This result can be justified by returning to screen characteristic where Al-Bireh have 60% percent of tissue paper and Al-Tira 29% and Jericho have 0 %. The tissue paper has ability to absorb water and this justifies high percent of water and low percent of solid in Al-Bireh and high percent of solid and low percent of water in Jericho. The figure (12) shows the percent of water and solid of screens 20 mm Al-Bireh, 6 mm Al-Tira, 5 mm Jericho with standard deviation.

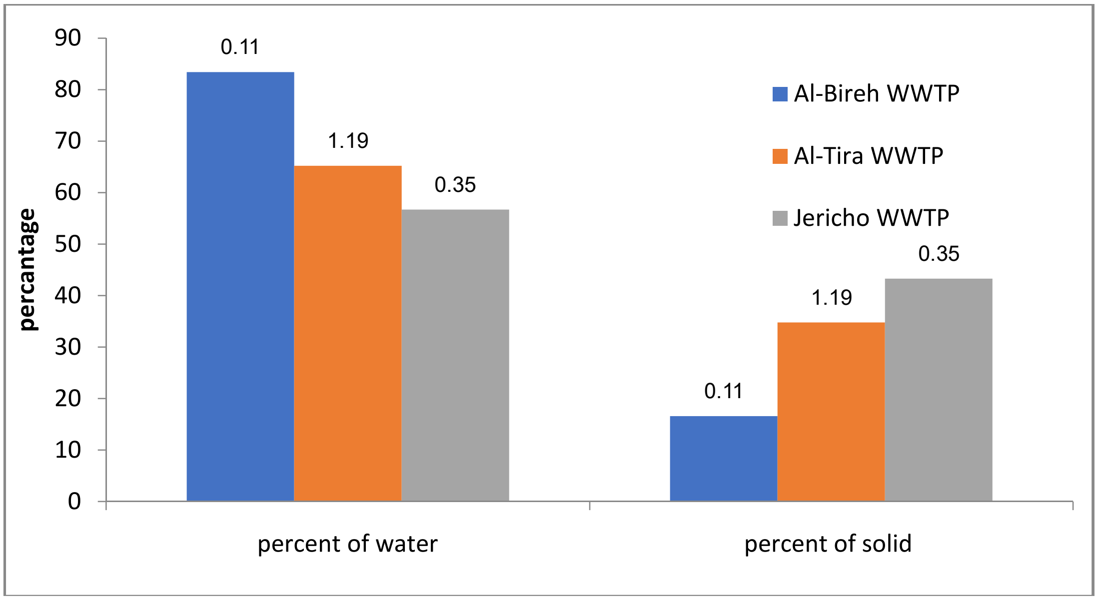

Figure 12| Percentage of water and solid of screen 20 mm Al-Bireh, 6 mm Al-Tira, 5 mm Jericho with standard deviation

4.2.2.3Density and Dry density

The result of density in three WWTP is (735.7 g/l in Al-Bireh,481.4 g/l in Al-Tira,444.6 g/l in Jericho) and result of dry density is (120 g/l in Al-Bireh, 167.3 g/l in Al-Tira,181.9 g/l in Jericho) as show in figure (13). Al-Bireh has highest density value a less dry density this because Al-Bireh have more than 60 % tissue paper where it can absorb high quantity of water and give weight, after put in oven all of this water evaporates so it's less value in dry density. Al-Tira has middle value in density and dry density, Jericho have less value of density and high value in dry density all that up to quantity of tissue paper and water.

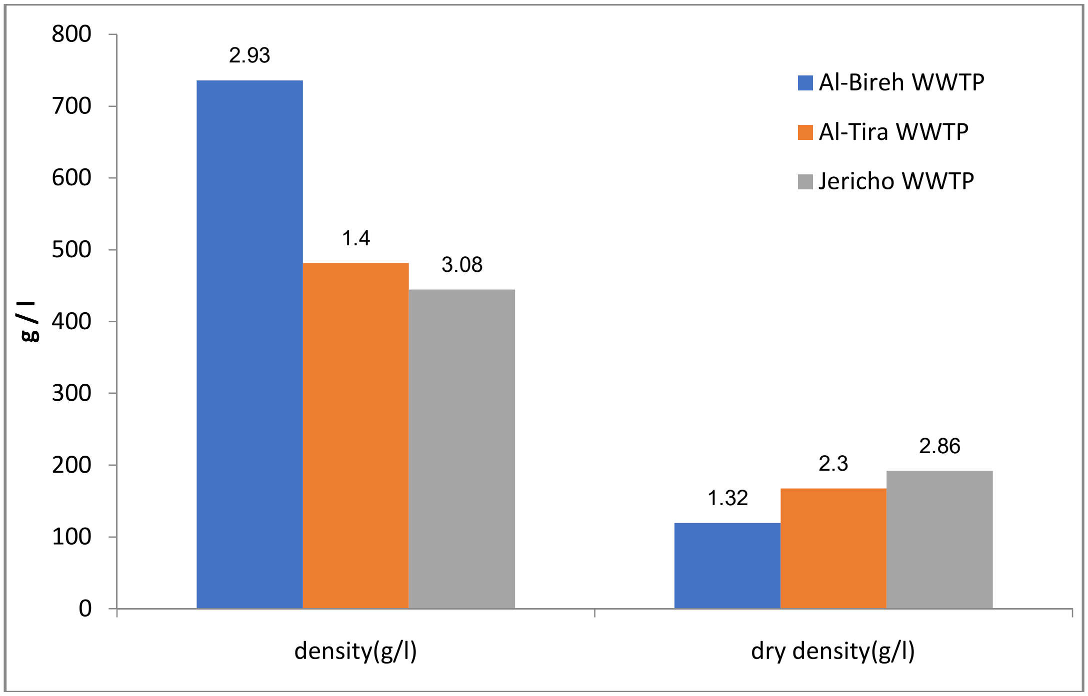

Figure 13| Density and dry density of screen 20 mm Al-Bireh,6 mm Al-Tira, 5 mm Jericho with standard deviation

4.2.1 Grit removal in Al-Bireh and Jericho and screen 2 mm in Al-Tira WWTP

5.2.3.1 Screening and grit characteristic

As shown in figure 14 and table 25 the characteristic of screen and grit in three WWTP, where have similarity of material removed in each size of sieve and notice different quantity removing of grit from waste water where Al-Bireh have 16.9% of sample is soil and Jericho have 8.3% soil and Al Tira have 4% soil, and this lead to different quantity of soil in waste water and different performance in removing of grit from waste water in three WWTP specifically Al-Tira have less percent this because there is no grit removal champers but have screen 2 mm and show Al-Tira have lowest percent of material less than 2 mm.

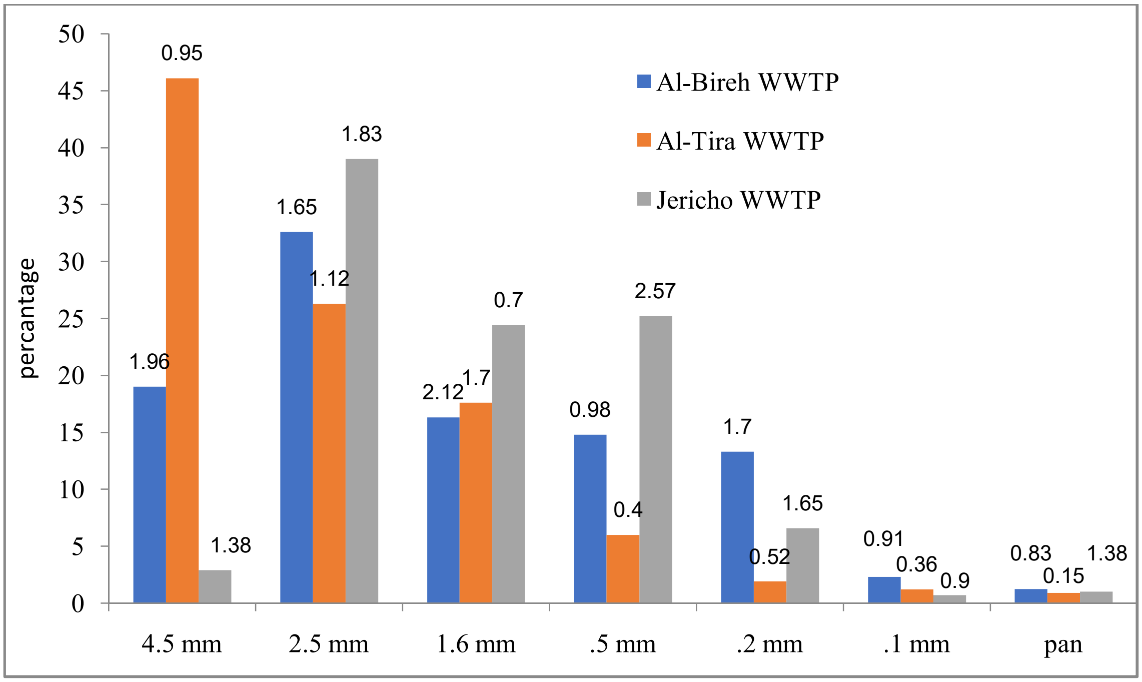

Figure 14| Percentage of characteristic grit in Al-Bireh, Jericho and screen 2 mm in Al-Tira with standard deviation

Table 25| Percentage of characteristic grit in Al-Bireh, Jericho and screen 2 mm in Al-Tira with description

Sieve open size	Al-Bireh	Al-Tira	Jericho	Description Material
4.5 mm	19	46.1	2.9	Nuts,straw ,soft paper trees and small tissue paper
2.5 mm	32.7	26.3	39	Nuts ,straw ,vegetable seeds ,soft paper trees and small stones
1.6 mm	16.3	17.6	24.4	Straw , vegetable seeds and small stones
.5 mm	14.8	6	25.2	Small Stones and straw
.2 mm	13.3	1.9	6.6	Soil
.1 mm	2.3	1.2	0.7	Soil
Pan(less .1 mm)	1.3	0.9	1	Soil

4.2.3.2 Percentage of water and solids.

As similar all sample of screen most of grit sample is water with difference in proportion where Al-Tira has high percent by 79% then Al-Bireh 70% then Jericho 64% as show in figure (15). By returning to characteristic can see Al-Tira has high percent of sieve size 4.5 mm, this size contain material can absorb water more than other and this applies at Al-Bireh where contain less material at size 4.5 mm but Jericho have lowest percent of water and that's because the same reason. That does not mean other material does not absorb water but tissue paper can absorb more than other absorbs and give high effect in percent of water.

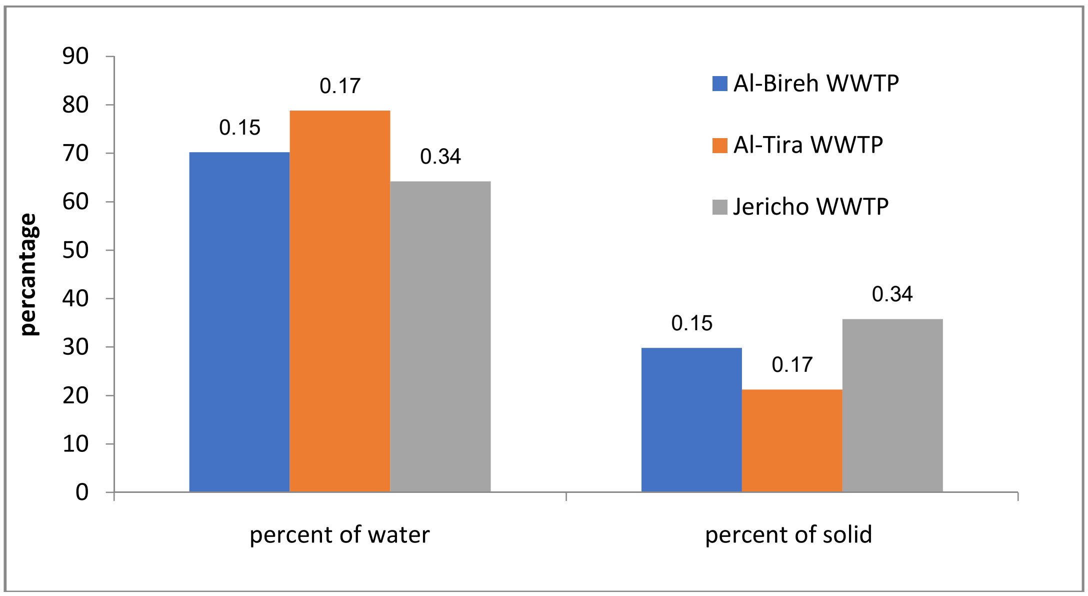

Figure 15| Percentage of water and solid of grit in Al-Bireh, Jericho and screen 2 mm in Al-Tira with standard deviation

4.2.3.3 Density and Dry density.

The figure (16)show the density and dry density of grit sample in three WWTP with standard deviation, where the result in Al-Bireh is (809.5g/l, 240.4 g/l) and Al-Tira (619 g/l, 131 g/l) and Jericho (723.8 g/l,259.5g/l). Its notice Al-Birehhas highest value of density and second value of dry density, Jericho have second value of density and highest value of dry density but very close to Al-Bireh value, this because there's similarity between removed material with increase percent of material can absorb water in Al-Bireh. Al-Tira has lowest value in density and dry density this because contain small percent of soil and stone and high percent of material can absorb water but it was not enough to be highest density.

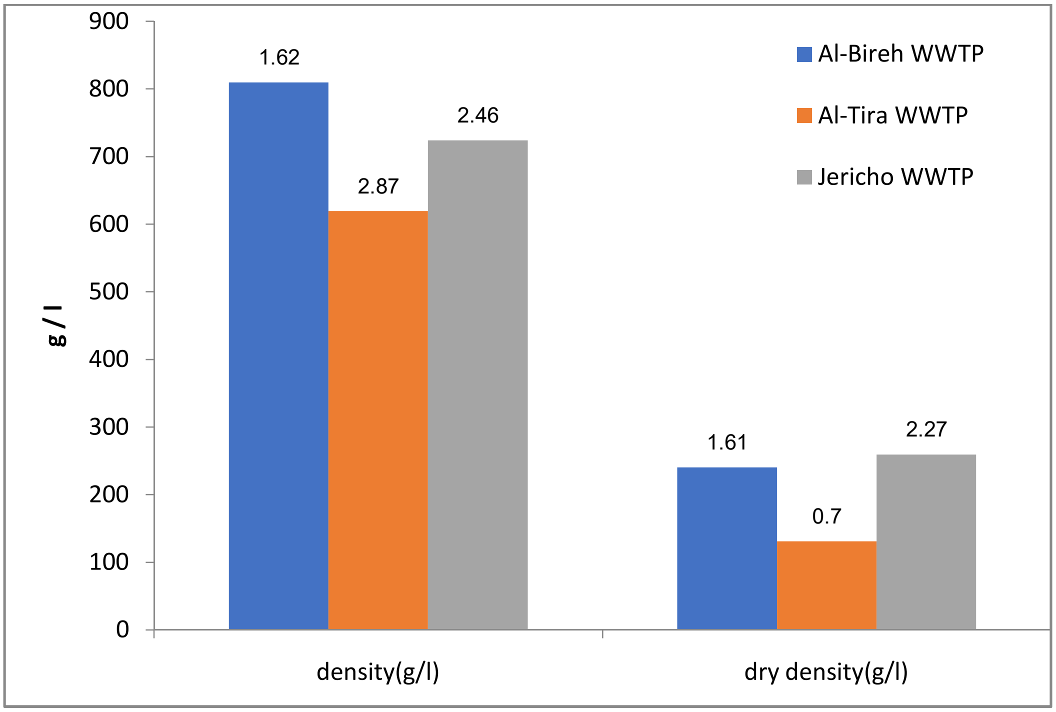

Figure 16 | Density and dry density of grit in Al-Bireh, Jericho and screen 2 mm in Al-Tira with standard deviation

4.2.4 Scum removal in Jericho WWTP

5.2.4.1 Scum characteristic

The scum removal not found in A-Tira and Al-Bireh WWTP, just find in Jericho and its mission remove all material floating on the surface of water. The figure (17) show characteristic sample of scum removal with standard deviation, where all of material light weight like Straw and Leave with percent (50%),Plactic2.7%, Vegetables seeds 25%, Nuts 4% and small stone and soil 18%.

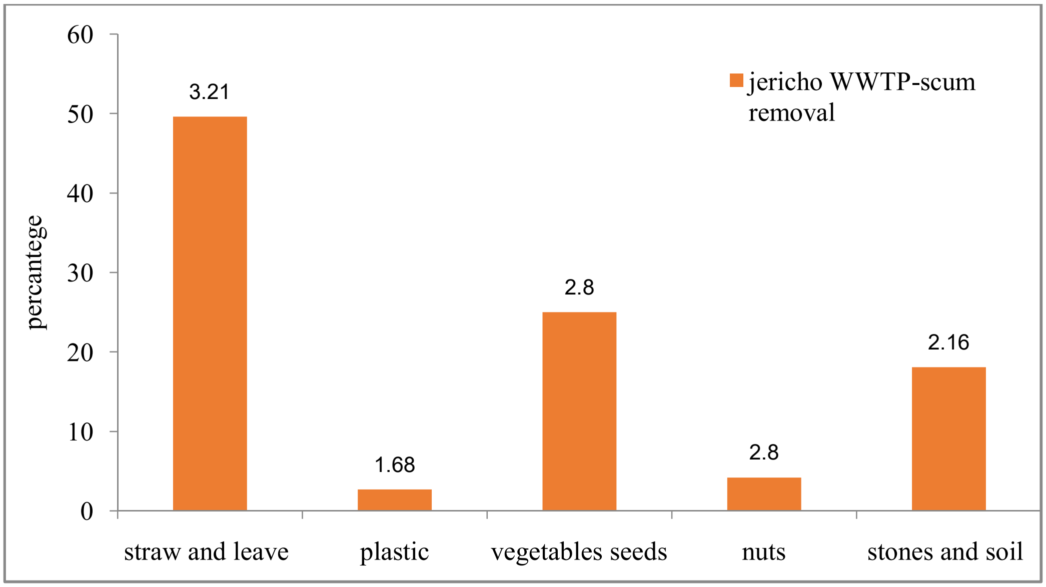

Figure 17| Characteristics of scum removal in Jericho WWTP with standard deviation

4.2.4.2 Percentage of water and solids, density and dry density.

Back to scum characteristic, all of material lightweight and have ability to absorb water as notice in figure (18) the percent of water around 65% and solid 35%,this percent give gap between density and dry density where density is 462 g/l and dry density is 161 g/l.

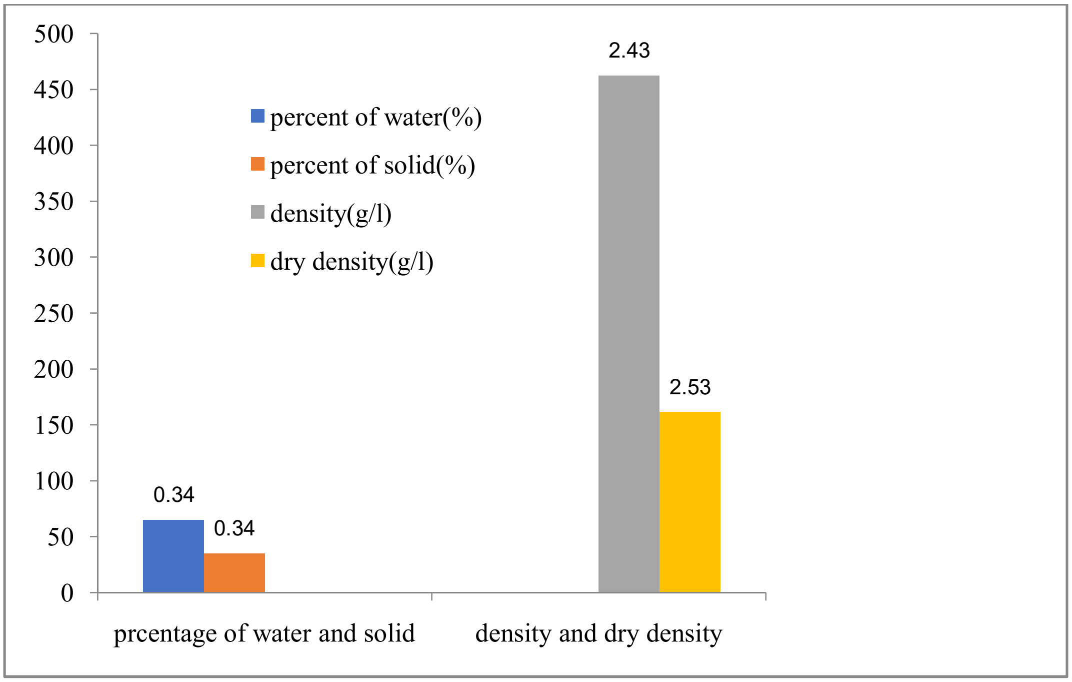

Figure 18| Percentage of water and solid, density and dry density of scum removal in Jericho WWTP with standard deviation

Back to section Types and quality of screening in literature review (Kuhn and Gregor, 2013) and (Hanben, 1999) mentioned the type of material can find in screening removal like condoms, hair, crow, toys, caps, medical dipsticks, bottle caps from liquid soap, articles of clothes, cigarette ends, cleaning wipes, lighters, glasses, where a lot of material mentioned was found during the analysis of screen sample.

(Environmental Protection Agency 1995) say density of screening is 600 - 950 kg/m3 and water percent 70% - 90% but didn't specify what open size of screen, and back to all reading in three WWTP at all open size notice the range of density from 444 g/l to 902 g/l .The range percent of water is 57% to 83% in all of screen open size in three WWTP.

Hanben(1999) say Mineral compound such as sand, grit and stones have percentage (3.5-9.5) %, this in separate system but in combine system finds higher percentages, this is clearly noted in results where the percent of material less than 0.2 mm in Al-Birehis 16.9% of grit removal sample knowing Al-Birah has combined system but the percent in Jericho is 8.3, knowing Jericho has separate system.

4.3 Storage, collection and disposal of screenings and grit

The storage and collection in three WWTP is the same where the waste after remove from screen and grit chamber put in container size varies from plant to plant until it's full after that municipal waste collection vehicle emptying containers inside. Disposal is different between three WWTP, in Al-Bireh the screen waste goes with Al-Bireh municipal solid waste to Zahret Al-Finjan dumpsite and the grit put with sludge in the plant after that go to Zahret Al-Finjan dumpsite. In Jericho the screen and grit waste go with Jericho municipal solid waste to the Jericho dumpsite. In the past in Al-Tira the screen waste go to dumpsite in Industrial Zone and to the Zahret Al-Finjan dumpsite but now the waste go to empty land inside the city. As mentioned by several authors, the screening and grit wastes disposal is neglected in literature in (Sidwick, 1991; Le Hyaric*et al*., 2009; Cadavid-Rodríguez, 2013). As was noticed in three WWTP no any criteria when disposal of waste, knowing this waste contain high percent of water with pollutant because it mix between waste water and solid waste .in European the land fill not allow to waste contain more 70% water, as shown in quality part most sample contain around 70% and more so as European not allow this waste go to land fill.

Chapter Five

Conclusions and recommendations

Quantitative and qualitative characteristics of material generation from screenings and grit on three municipal wastewater treatment plants (WWTPs) in West Bank (Palestine) were determined in this study, as a first step towards the development of an appropriate management strategy and disposal for these wastes. The selected WWTPs had nearly the same treatment capacity and were equipped with gap sizes of the screens ranging from 50 to 2 mm and two plants have a grit removal.

Quantitatively, the annual generation rates per capita calculated from the results presented in this Thesis there was a lot difference between each plant, from 0.1 to 2.64 kg (wet mass). The waste production was affected by many factors such as the minimal gap size of the screens, the type of sewer system separate or combined and the presence of grit removal champers or not. Qualitatively, also affected by the same factors where it affects at the natural and characteristics of material removed from each size of screens and grit removal.

Screenings sampled from the 5-mm to the 60-mm screens were manually sorted into 12 fractions of waste materials, 1mm screenings sampled and grit removal were analyzed by sieve analyses (4.5mm –0.1mm) into 7 category of waste material in order to determine their composition. The composition and characteristics of the wastes was shown slightly different among the three WWTPs studied.

Based on these data, other types of analyses concerning physical and biological properties will be conducted to evaluate the feasibility of different treatment options. The final objective is to develop an adapted management strategy considering both the waste characteristics and the local situations.

It is recommended give more attention to the waste removed from screen and grit because this research show the large quantity of material removed from three WWTP, where 87778 kg/y (dry mass) removed from three WWTP and its huge number and worth big attention. It should be noted to disposal of this waste because contain large quantity of water must give more attention and treat it differently from municipal waste and notice poor information of the consumers who often through their sanitary textiles into the toilets while they have to discard them with the household solid waste so awareness of this situation must be increase. And recommended back to these results when deicide the number of screen and minimal sized of open screen and compared to efficiency of grit removal chamber and recommended.

These results are very important in the stage of WWTP design where through it can calculate all quantity of waste production from screening and grit removal and calculate the disposal cost of this waste.

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Annex 1: Readings and calculations of quantity of screenings and grits in three WWTP

1- AL-Bireh WWTP

1.1 Reading of quantity generation from Screen 50 mm in Al-Bireh WWTP with standard deviation.

Start date	End date	Time (h)	Volume (m3)	L/d
11/7/2021 at 12:00	2/8/2021 at 13:00	529 h	.62	28.1
2/8/2021 at 13:00	28/8/2021 at 11:00	622	.66	25.4
28/8/2021 at 11:00	21/9/2021 at 11:00	576	.63	26.25
avg				26.55
Standard deviation				1.38

1.2 Reading of quantity generation from Screen 20 mm in Al-Bireh WWTP with standard deviation.

Start date	End date	Time (h)	Volume (m3)	L/D
11/7/2021 at 12:00	2/8/2021 at 13:00	529 h	.66	29.94
2/8/2021 at 13:00	28/8/2021 at 11:00	622	.7	27
28/8/2021 at 11:00	21/9/2021 at 11:00	576	.68	28.3
avg				28.4
Standard deviation				1.47

1.3 reading of quantity generation from grit removal in Al-Bireh WWTP with standard deviation

Start date	End date	Time (h)	Volume (m3)	L/D
8/7/2021 at 8:10	15/7/2021 at 8:40	168 h and 30 min	5.1	728.5
15/7/2021 at 8:40	24/7/2021 at 9:10	216 h and 30 min	6.5	722
24/7/2021 at	2/8/2021 at	193 h and 50	5.8	718.2

9:10	11:00	min		
2/8/2021 at 11:00	8/8/2021 at 8:30	141h and 30 min	4.3	729.3
avg				724.7
Standard deviation				3.75

1.4 Calculating the quantities produced from each size of screen and grit in Al-Bireh WWTP

	Avg l/d	**Wet Density(g/l)**	**Kg /d(wet)**	**People served**	**Kg/c/y(wet)**	**l/c/y**
Screen 50 mm	26.55	791.9	21	83700	0.09	0.11
Screen 20 mm	28.4	735.7	20.89	83700	.089	0.12
Grit removal	724.7	809.5	586.6	83700	2.52	3.11

1.5 Calculating the quantities produced from each size of screen and grit in Al-Bireh WWTP

	Avg l/d	**Dry Density(g/l)**	**Kg /d(dry)**	**People served**	**Kg/c/y(dry)**
Screen 50 mm	26.55	131.2	3.48	83700	.0149
Screen 20 mm	28.4	119.5	3.39	83700	.0145
Grit removal	724.7	240.4	174.2	83700	.75

1.6 Final results of quantities produced from each size of screen and grit in Al-Bireh WWTP

	l/d	**Kg / d (dry mass)**	**Kg / d (wet mass)**	**l/c/y**	**Kg/c/y(dry mass)**	**Kg/c/y(wet mass)**
Screen 50mm	26.55	3.48	21	0.11	0.0149	0.09
Screen 20 mm	28.4	3.39	20.89	0.12	0.145	0.89
Grit	724.7	171.8	586.6	3.11	0.75	2.52
sum	779.65	178.67	628.49	3.34	0.9	3.5

2 Al-Tira WWTP

2.1 Reading of quantity generation from Screen 50 mm in Al-Tira WWTP with standard deviation.

Start date	End date	Time (h)	Volume (m3)	L/D
31/7/2021 at 11:00	7/8/2021 at 12:00	169 h	.042	5.95
7/8/2021 at 12:00	14/8/2021 at 12:00	168	.05	7.12
14/8/2021 at 12:00	21/8/2021 at 11:00	167	.042	5.92
21/8/2021 at 11:00	28/8/2021 at 13:00	170	.051	7.2
28/8/2021 at 13:00	11/9/2021 at 12:00	335	.094	6.72
AVG				6.58
Standard deviation				0.55

2.2 Reading of quantity generation from Screen 6 mm in Al-Tira WWTP with standard deviation.

Start date	End date	Time(h)	Volume (m3)	L/D
7/8/2021 at 10:00	14/8/2021 at 12:00	170	.12	16.94
14/8/2021 12:00	21/8/2021 at 11:00	167	.12	17.24
21/8/2021 at 11:00	28/8/2021 at 13:00	170	.127	17.92
28/8/2021 at 13:00	11/9/2021 at 12:00	335	.247	17.69
AVG				17.44
Standard deviation				0.58

2.3 Reading of quantity generation from Screen 2 mm in Al-Tira WWTP with standard deviation.

Start date	End date	Time(h)	Volume (m3)	L/D
31/7/2021 at 9:00	7/8/2021 at 9:30	168 h and 30 min	.81	115.3
7/8/2021 at 9:30	14/8/2021 at 9:00	167 and 30 min	.82	117.49
14/8/2021 at 9:00	24/8/2021 at 4:00	247 h	1.227	119.2
24/8/2021 at 4:00	4/9/2021 at 9:00	257 h	1.3	121.4
4/9/2021 at 9:00	11/9/2021 at 13:00	88 h	.42	114.54
AVG				117.58
Standard deviation				2.5

2.4 Calculating the quantities produced from each size of screen and grit in Al- Tira WWTP.

	Avg l/d	wet Density(g/l)	Kg /d(wet)	People served	Kg/c/y(wet)
Screen 50 mm	6.58	638.2	4.2	25000	.061
Screen 6 mm	17.44	481.4	8.39	25000	.122
Screen 2 mm	117.58	619.2	72.8	25000	1.06

2.5 Calculating the quantities produced from each size of screen and grit in Al- Tira WWTP.

	Avg l/d	Dry Density(g/l)	Kg /d	People served	Kg/c/y
Screen 50 mm	6.58	121.7	.8	25000	.011
Screen 6 mm	17.44	163.9	3.419	25000	.05
Screen 2 mm	117.58	131	15.4	25000	.22

2.6 Final results of quantities produced from each size of screen in Al-Tira WWTP.

	l/d	Kg / d (dry)	Kg / d (wet)	l/c/y	Kg/c/y(dry)	Kg/c/y(wet)
Screen 50 mm	6.58	0.8	4.2	0.096	0.011	0.061
Screen 6 mm	17.44	3.41	8.39	0.25	0.05	0.122
Screen 2 mm	117.58	15.4	72.8	1.71	0.22	1.06
sum	141.6	19.61	85.39	2.056	0.281	1.243

3 Jericho WWTP

3.1 Reading of quantity generation from Screen 50 mm in Jericho WWTP with standard.

Start date	End date	Time(h)	Volume (m3)	L/D
24/10/2021 at 9:00	13/11/2021 at 9:00	480	0.5	25
13/11/2021 at 9:00	28/11/2021 at 9:00	360	0.5	33.3
28/11/2021 at 9:00	16/12/2021 at 9:00	432	0.5	27.7
16/12/2021 at 9:00	3/1/2022 at 9:00	432	0.5	27.7
AVG				28.42
Standard deviation				3

3.2 Reading of quantity generation from Screen 5 mm in Jericho WWTP with standard.

Start date	End date	Time(h)	Volume (m3)	L/D
24/10/2021 at 9:00	13/11/2021 at 9:00	480	.6	30
13/11/2021 at 9:00	28/11/2021 at 9:00	360	.5	33.3
28/11/2021 at 9:00	16/12/2021 at 9:00	432	.5	27.7
16/12/2021 at 9:00	3/1/2022 at 9:00	432	.5	27.7
AVG				29.7
Standard				2.29

deviation				

3.3 Reading of quantity generation from grit removal in Jericho WWTP with standard.

Start date	End date	Time(h)	Volume (m3)	L/D
24/10/2021 at 9:00	13/11/2021 at 9:00	480	2.7	135
13/11/2021 at 9:00	28/11/2021 at 9:00	360	2	133.3
28/11/2021 at 9:00	16/12/2021 at 9:00	432	2.3	127.7
16/12/2021 at 9:00	3/1/2022 at 9:00	432	2.3	127.7
AVG				130.9
Standard deviation				3.28

3.4 Reading of quantity generation from scum removal in Jericho WWTP with standard.

Start date	End date	Time(h)	Volume (m3)	L/D
24/10/2021 at 9:00	13/11/2021 at 9:00	480	.4	20
13/11/2021 at 9:00	28/11/2021 at 9:00	360	.25	16.7
28/11/2021 at 9:00	16/12/2021 at 9:00	432	.25	13.9
16/12/2021 at 9:00	3/1/2022 at 9:00	432	.25	13.9
AVG				16.1
Standard deviation				2.5

3.5 Calculating the quantities produced from each size of screen and grit in Jerich WWTP.

	Avg l/d	wet Density (g/l)	Kg /d(wet)	People served	Kg /c/y(wet)
Screen 50 mm	28.42	902.2	25.6	25000	0.369
Screen 5 mm	29.7	444.6	13.19	25000	0.19
Grit removal	130.9	723.8	94.74	25000	1.364
Scum removal	16.1	462.3	7.44	25000	0.1

3.6 Calculating the quantities produced from each size of screen and grit in Jerich WWTP.

	Avg l/d	Dry Density (g/l)	Kg /d(dry)	People served	Kg /c/y(dry)
Screen 50 mm	28.42	193.3	5.49	25000	.079
Screen 5 mm	29.7	191.9	5.69	25000	.082
Grit removal	128.4	259.5	33.3	25000	0.479
Scum removal	16.1	161.6	2.6	25000	0.037

3.7 Final results of quantities produced from each size of screen in Al-Tira WWTP.

	l/d	Kg / d (dry)	Kg / d (wet)	l/c/y	Kg/c/y(dry)	Kg/c/y(wet)
Screen 50mm	28.42	5.49	25.6	0.4	0.079	0.369
Screen 5 mm	29.7	5.69	13.19	0.42	0.082	0.19
Grit	130.9	33.3	94.74	1.88	0.479	1.364
scum	16.1	2.6	7.44	0.23	0.037	0.1
	205.18	47.08	140.97	2.57	.677	2.02

Annex 2: Readings and calculations of quality of screening and grit in three WWTP

1- AL – Bireh WWTP

1.1 Quality of material generation from Screen 50 mm in Al-Bireh WWTP.

	Sample 1	Sample 2	Sample 3	avg	Standard deviation
Volume (L)	1	1	1		
Weight before dry(g)	770.3	767.4	764		
Weight after dry(g)	131.5	131	136		
Percent of water (w%)	83%	82.9%	82.1%	83.3%	0.5
Percent of solid (s%)	17%	16.6%	16.7%	16.7%	0.5
Density (g/l)	770.3	767.4	764	791.9	3.15
Dry density (g/l)	131.5	131	136	131.2	2.75

1.2 Sorting of material generation from screen 50 mm in Al-Bireh WWTP.

Fraction	Sample 1 (g)	Sample 2 (g)	Sample 3 (g)	Avg.	Percent	Standard deviation
Plastic	14.8	9.6	9.1	11.1	8.44%	3.15
Animals	2.4	.9	0	1.1	0.8%	1.21
Tissue paper	46.4	52.4	44.7	46.5	35.3%	1.85
cloth	28.7	26.7	35.3	31.5	24%	3.38
soil	9.6	12.4	10	10.6	8%	1.51
Leaves and pieces of wood	5.3	3.3	6.2	4.93	3.75%	1.48
other	23.6	24	28.9	25.5	19.4%	2.95
Total weight	130.8	129.3	134.2	131.4	100%	2.51

1.3 Quality of material generation fromScreen 20 mm in Al-Bireh WWTP.

	Sample 1	Sample 2	Sample 3	Avg.	Standard deviation
Volume (L)	1	1	1		
Weight before dry	733.1	738.9	735.2		
Weight after dry	118.5	121	119		
Percent of water (w%)	83.8%	83.6%	83.8%	83.4%	0.11
Percent of solid (s%)	16.2%	16.4%	16.3%	16.6%	0.11
Density (g/l)	733.1	738.9	735.2	735.7	2.93
Dry density (g/l)	118.5	121	119	119.5	1.32

1.4 Sorting of material generation from screen 20 mm in Al-Bireh WWTP.

Fraction	Sample 1 (g)	Sample 2 (g)	Sample 3 (g)	Avg.	Percent	Standard deviation
Glass	4.2	8.3	7.1	6.5	5.5%	2.1
Plastic	12.4	8.4	13.5	11.4	9.6%	2.68
Leaves and pieces of wood	3.3	5.2	6.4	4.9	4.4%	1.56
Animals	4	2.2	0	2	1.7%	2
Vegetables	6.7	5.4	3.2	5.1	4.3%	1.76
Nuts	2.2	4.7	3.5	3.4	2.9%	1.25
Cigarettes	0	3.7	4.1	2.6	2.2%	2.26
Tissue paper and hair	74.5	70.3	72.6	72.4	61.2%	2.1
Soil and small stone	9.4	12.2	8.5	10	8.5%	1.92
straw	0	0	0	0	0%	0
others	0	0	0	0	0%	0
Total weight	116.7	120.4	118.9	118.6	100%	1.86

1.5 Quality of material generation from grit removal in Al-Bireh WWTP.

	Sample 1	Sample 2	Sample 3	Avg	Standard deviation
Volume (L)	1	1	1		
Weight before dry	809	808.3	811.4		
Weight after dry	241.3	238.6	241.5		
Percent of water (w%)	70.1%	70.4%	70.2%	70.2%	0.15
Percent of solid (s%)	29.9%	29.6%	29.8%	29.8%	0.15
Density (g/l)	809	808.3	811.4	809.5	1.62
Dry density (g/l)	241.3	238.6	241.5	240.4	1.61

1.6 Sorting of material generation from grit removal in Al-Bireh WWTP.

	Sample 1	Sample 2	Sample 3	avg	percent	Descprition	Standard deviation
4.5 mm	43.8	47.7	45.3	45.6	19%	Nuts, straw and soft paper trees	1.96
2.5 mm	80	76.7	78.2	78.3	32.7%	Nuts,straw,vegetable seeds,soft paper trees and small stones	1.65
1.6 mm	37.2	38.7	41.4	39.1	16.3%	Straw, vegetable seeds and small stones	2.12
.5 mm	35.7	34.3	36.2	35.4	14.8%	Small Stones and straw	0.98
.2 mm	33.6	32	30.2	31.9	13.3%	Soil	1.7
.1 mm	6.6	4.8	5.4	5.6	2.3%	Soil	0.91
Pan(less .1 mm)	3.3	2.1	3.7	3	1.25%	Soil	0.83
Total weight	240.2	236.3	240.4	238.9	100%		2.31

2- Al-Tira WWTP

2.1 Quality of material generation from Screen 50 mm in Al-Tira WWTP.

	Sample 1	Sample 2	Sample 3	Avg	Standard deviation
Volume (L)	1	1	1		
Weight before dry	642.2	634.4	638.2		
Weight after dry	120.2	119.9	122.6		
Percent of water (w%)	81.2%	82.6%	80.7%	81.5%	0.98
Percent of solid (s%)	18.8%	17.3%	19.3%	18.5%	0.98
Density (g/l)	642.2	634.4	638.2	638.2	3.1
Dry density (g/l)	120.2	119.9	122.6	121.7	1.47

2.2 Sorting of material generation from screen 50 mm in Al-TiraWWTP.

Fraction	Sample 1 (g)	Sample 2 (g)	Sample 3 (g)	Avg	percent	Standard deviation
Plastic	5.4	10.2	7.9	7.8	6.6	2.4
animal	2.2	1.9	0.8	1.6	1.4	0.73
Tissue paper	40.8	36.7	42.3	39.9	31.3	2.89
Clothes	52.7	46.9	46.9	48.8	42.2	3.34
Soil	9	12.5	14.7	12	10.2	2.87
Leaves and pieces of wood	1.7	3.3	0.7	1.9	1.6	1.3
Other	7.4	8.2	8.4	8	6.8	.52
Total weight	119	119.7	121.7	120.1	100%	1.4

2.3 Quality of material generation from Screen 6 mm in Al-Tira WWTP.

	Sample 1	**Sample 2**	**Sample 3**	**Avg**	**Standard deviation**
Volume (L)	1	1	1		
Weight before dry	479.9	482.6	481.9		
Weight after dry	165.1	167.1	169.7		
Percent of water (w%)	65.5%	65.3%	64.7%	65.2%	1.19
Percent of solid (s%)	34.5%	34.7%	35.3%	34.8%	1.19
Density (g/l)	479.9	482.6	481.9	481.4	1.4
Dry density (g/l)	165.1	167.1	169.7	167.3	2.3

2.4 Sorting of material generation from screen 6 mm in Al-Tira WWTP.

Fraction	Sample 1 (g)	Sample 2 (g)	Sample 3 (g)	Avg.	percent	Standard deviation
Glass	8.4	10.5	9.6	9.5	5.9%	1
Plastic	16.6	13.4	18.1	16	9.9%	2.4
Leaves and pieces of wood	6.2	7.3	9.4	7.6	4.7%	1.62
Animals	8.4	7.3	9.4	8.3	5.2%	1
Vegetables	7.7	8.2	0	5.3	3.3%	4.59
Nuts	7.4	6.5	5.7	6.5	4%	0.85
Cigarettes	6.2	5.4	7.8	6.4	4%	1.22
Tissue paper and hair	46.2	48.7	44.3	46.4	28.8%	2.2
Small stone and soil	14.2	16.4	18.7	16.4	10%	2.25
Straw	24.3	28.1	27.7	26.7	16.6%	2
Other	7.8	12.4	15.8	12	7.4%	4
Total weight	165.1	164	166.9	161.1	100%	1.46

2.5 Quality of material generation from Screen 2 mm in Al-Tira WWTP.

	Sample 1	Sample 2	Sample 3	Avg.	Standard deviation
Volume (L)	1	1	1		
Weight before dry	616.6	618.8	622.3		
Weight after dry	131.3	131.5	130.2		
Percent of water (w%)	78.7%	78.7%	79%	78.8	0.17
Percent of solid (s%)	21.3%	21.3%	21%	21.2%	0.17
Density (g/l)	616.6	618.8	622.3	619.2	2.87
Dry density (g/l)	131.3	131.5	130.2	131	0.7

2.6 Sorting of material generation from screen 2 mm in Al-Tira WWTP.

	Sample 1	Sample 2	Sample 3	Avg.	percent	Description	Standard deviation
4.5 mm	58.6	60.3	60.2	59.7	46.1	Nuts ,small stone ,leaves ,vegetable seeds straw and paper	0.95
2.5 mm	35.3	33.4	33.3	34	26.3	Leaves ,vegetable seeds, nuts ,straw and small stones	1.12
1.6 mm	24.5	22.9	21.1	22.8	17.6	Straw , vegetable seeds and small stones	1.7
.5 mm	7.7	7.3	8.1	7.7	6	Small Stones and straw	0.4
.2 mm	2	2.2	3	2.4	1.9	Soil	0.52

.1 mm	1.2	1.7	1.9	1.6	1.2	Soil	0.36
Pan(less .1 mm)	1.1	1.4	1.3	1.2	0.9	Soil	0.15
Total weight	130.4	129.2	128.9	129.4	100%		0.79

3- Jericho WWTP

3.1 Quality of material generation from Screen 50 mm in Jericho WWTP.

	Sample 1	Sample 2	Sample 3	Avg.	Standard deviation
Volume (liter)	1	1	1		
Weight before dry(g)	899	902.3	905.3		
Weight after dry(g)	195	193.6	191.3		
Percent of water (w%)	78.3%	78.5%	78.8%	78.5%	0.25
Percent of solid (s%)	21.7%	21.5%	21.2%	21.5%	0.25
Density (g/l)	899	902.3	905.3	902.2	3.15
Dry density (g/l)	195	193.6	191.3	193.3	1.86

3.2 Sorting of material generation from screen 50 mm in Jericho WWTP.

Fraction	Sample 1 (g)	Sample 2 (g)	Sample 3 (g)	Avg.	Percent	Standard deviation
Plastic	14.2	16	14.7	14.9	7.79%	0.9
Animals	0	3.4	0	1.1	0.6%	1.96
Tissue paper	63.7	59.3	53.3	58.7	30.7%	5.22
Cloth	45	39.6	42.4	42.3	22.1%	2.7
Soil	37.5	34.2	37	36.2	18.9%	1.77
Leaves and pieces of wood	0	4.2	2.8	2.3	1.2%	2.13
Other	33.2	33.5	39.8	35.5	3.72%	2.6
Total weight	193.6	190.2	190	191.2		1.86

3.3 Quality of material generation from Screen 5 mm in Jericho WWTP.

	Sample 1	Sample 2	Sample 3	AVG	Standard deviation
Volume (liter)	1	1	1		
Weight before dry(g)	440.8	448.4	444.8		
Weight after dry(g)	190.1	195.2	190.4		
Percent of water (w%)	56.8%	56.4%	57.1%	56.7%	0.35
Percent of solid (s%)	43.2%	43.6%	4.1%	43.3%	0.35
Density (g/l)	440.8	448.4	444.8	444.6	3.08
Dry density (g/l)	190.1	195.2	190.4	191.9	2.86

3.4 Sorting of material generation from screen 5 mm in Jericho WWTP.

Fraction	Sample 1 (g)	Sample 2 (g)	Sample 3 (g)	Avg.	percent	Standard deviation
Glass	24.3	23.4	26.4	24.7	13%	1.53
Plastic	23.4	22.3	18.4	21.3	11.2%	2.62
Leaves and pieces of wood	30.4	31.8	28.5	30.2	15.9%	1.65
Animals	20.5	23.2	21.3	21.6	11.4%	1.38
Vegetables	0	0	0	0	0%	0
Nuts	11.7	13.5	13.2	12.8	6.77%	0.96
Cigarettes	11.3	9.3	15.2	11.9	6.29%	3
Tissue paper and hair	0	0	0	0	0%	0
Soil and small stone	18.2	21.9	19.5	19.8	10.47%	1.87
Straw قش	27.3	26.7	31.3	28.4	15%	2.5
Other	20	21.1	14.6	18.5	9.78%	3.47
Total weight	187.1	193.2	188.4	189.5	100%	3.21

3.5 Quality of material generation from grit removal in Jericho WWTP.

	Sample 1	Sample 2	Sample 3	Avg.	Standard deviation
Volume (liter)	1	1	1		
Weight before dry(g)	721	725.5	725		
Weight after dry(g)	260.2	261.4	257		
Percent of water (w%)	63.9%	63.9%	64.5%	64.2%	0.34
Percent of solid (s%)	35.2%	36.7%	35.5%	35.8%	0.34
Density (g/l)	721	725.5	725	723.8	2.46
Dry density (g/l)	260.2	261.4	257	259.5	2.27

3.6 Sorting of material generation from screen 5 mm in Jericho WWTP.

	Sample 1	Sample 2	Sample 3	Avg.	Percent	description	Standard deviation
4.5 mm	7.9	8.7	6	7.53	2.9%	Nuts and leaves	1.38
2.5 mm	99	102.5	101.7	101	39%	Leaves, straw ,vegetable seeds and small stones	1.83
1.6 mm	64	62.6	63.1	63.2	24.4%	Straw , vegetable seeds and small stones	0.7
.5 mm	62.3	67.1	66.3	65.2	25.2%	Small Stones and straw	2.57
.2 mm	18.8	16.9	15.5	17	6.58%	Soil	1.65
.1 mm	2.8	1.3	1.1	1.7	0.7%	Soil	0.9
Pan(less .1 mm)	4.1	1.6	1.8	2.5	1%	soil	1.38
Total weight	258.9	260.6	255.5	258.3			1.38

3.7 Quality of material generation from scum removal in Jericho WWTP.

	Sample 1	Sample 2	Sample 3	Avg.	Standard deviation
Volume (liter)	1	1	1		
Weight before dry (g)	468.3	463.5	465.2		
Weight after dry(g)	168	163.2	167		
Percent of water (w%)	64.1%	64.7%	64.1%	65%	0.34
Percent of solid (s%)	35.9%	35.3%	35.9%	35%	0.34
Density (g/l)	468.3	463.5	465.2	462.3	2.43
Dry density (g/l)	168	163.2	167	161.6	2.53

3.8 Sorting of material generation from screen 5 mm in Jericho WWTP.

Fraction (g)	Sample 1 (g)	Sample 2 (g)	Sample 3 (g)	Avg.	Percent	Standard deviation
Straw and leaves	78.2	83	84.3	81.8	49.6%	3.21
Plastic	3.1	4.2	6.4	4.5	2.7%	1.68
Vegetables seeds	43.3	38.6	42.2	41.3	25%	2.8
Nuts	9.9	6.7	4.3	6.9	4.19%	2.8
Stones and soil	32.3	29.3	28.1	29.9	18.1%	2.16
Total weight	166.8	161.8	165.3	164.6	100%	2.56

Annex 3: Photos

Photo (1): container of screen 50 mm in Al Bireh WWTP

Photo (2): container of screen 20 mm in Al Bireh WWTP

Photo (3): container of grit removal in Al Bireh WWTP


Photo (4): container of screen 6 mm in Al Tira WWTP


Photo (5): container of screen 2 mm in Al Tira WWTP


Photo (6): container of screen 50 mm in Jericho WWTP

Photo (7): container of screen 20 mm in Jericho WWTP

Photo (8): container of grit removal in Jericho WWTP

Photo (10): container of scum removal in Jericho WWTP

Photo (11): plastic from characteristic of screen 20 mm

Photo (12): Cigarettes

Photo (13): Animal


Photo (14): characteristic of screen 50 mm

Photo(15): sieve analysis

Photo(16): sieve analysis

Photo(17): soil production from grit sample