Potentiality of Waste Water Reusing in Iraq

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ABSTRACT

Reusing of treated wastewater effluent, which is normally discharged to the environment from municipal waste water treatment plants, is receiving an increasing attention as a reliable water resource. The volume of this resource may be worthily taken into consideration in the planning and implementations of water resources projects.

Currently most of the Middle East countries have developed their own experience in this field, however, among these countries Iraq has nothing to do in this field, a case which make one feels sorrowful. Therefore, in this work, such techniques have been analytically discussed, and handy systems of drip irrigation methods for using treated waste water in Iraq have been proposed. Moreover, in this paper, a pioneer research study has been carried out as a leading effort on this promising field of recycling wastewater usage in Iraq.

For the time being, it has been detected that about 1 million cubic meters in the city of Baghdad only is disposed every day to Tigris river after getting secondary treatment, It has been shown that in 2020 the amount of wastewater in the city of Baghdad may increased to as much as (4388264) m3/day, which (if treated) may irrigate as much as (43882)hectare of industrial crops, or to be used for planting a green belt of trees surrounding the whole city of Baghdad, this could help in damping the dust storms which became a predominant phenomena in the last few years.

It is also shown that the concept of decentralization sewage treatment plants and separation of gray water in source may be the most dare steps to be taken by the authorities to comply with the new era of water reuse management in Iraq.

Keywords: Water reuse, Reclaimed Water, Drip irrigation, Wastewater management.

امكانية اعادة استخدام مياه الصرف الصحي لنظام الري بالتنشيط في المناطق الريفية في العراق

الخلاصة

إن إعادة استخدام مياه الصرف الصحي المعالجة والتي تطرح عادة إلى البيئة من محطات معالجة مياه الصرف الصحي البلدية ، تحظى اهتماما متزايدا كمورد مائي مهما وواعدا. أن حجم هذا المورد يجب أن

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يؤخذ بعين الاعتبار في التخطيط والتنفيذ لمشاريع الموارد المائية المختلفة والتي تنفذ اليوم في عدة مجالات تقريبا وخاصة في المناطق القاحلة في مختلف أنحاء العالـم.
حاليا إن معظم بلدان الشرق الأوسط قد طورت خبراتها الخاصة في هذا المجال، ومع الاسف من بين هذه الدول العراق لم يكن لديه نصيب في هذا المجال.
في هذا البحث، تم مناقشة التقنيات المتاحة لفصل مياه الصرف الصحي الخفيفة في مصدرها، إذ تم تحليل واقتراح أساليب مفيدة من أنظمة الري بالتنقيط لاستخدام هذا النوع من مياه الصرف الصحي المعالجة.
كما تم أيضا إجراء دراسة بحثية تمثل جهدا رائدا في هذا المجال لإعادة تدوير مياه الصرف الصحي الحالية في العراق. وفي الوقت الحالي يطرح تقريبا (1) مليون متر مكعب في مدينة بغداد في كل يوم لنهر دجلة بعد اجراء المعالجة الثانوية عليها، ويمكن استخدام معظم هذه الكمية كونها تكفي لري مساحة تقدر بـ (43882) هكتار.
في عام 2020 قد تصل كمية مياه الصرف الصحي في مدينة بغداد بمقدار (4388264) م^3/يوم , ولو تم معالجتها ستكفي لري مساحة تقدر بـ (43882) هكتار من المحاصيل الصناعية , أو لزراعة حزام أخضر من الأشجارحول مدينة بغداد والذي سيساعد في صد او تخفيف العواصف الترابية التي أصبحت ظاهرة سائدة في السنوات الاخيرة.
ومن ألاستنتاجات المهمة للبحث الحالي أن تقوم الجهات المعنية بتنفيذ مشاريع معالجة مياه الصرف الصحي باخذ خطوات جريئة في انتهاج اسلوب اللامركزية في اختيار مواقع هذه المشاريع مما سيساعد على استخدام المياه المعالجة في مواقعها الجغرافية.

الكلمات المرشدة :تدوير واستخدام المياه, تأهيل واستصلاح المياه, الري بالتنقيط, ادارة مياه الصرف.

INTRODUCTION

Treated water is a valuable resource that should not be wasted. Humans have always realized the importance of water to life have given top priority to using it wisely [1]. The rapid urbanization increase the pressure on the resources, leading to increasing costs of water supply and emphasizing on the need for appropriate water management practices. Approximately 60% of the populations in any region are connected to sewerage system [2]. In Iraq, for example, it is a common practice to discharge untreated sewage directly into bodies of water causing significant health and economic risks. Several research studies showed that, treated wastewater, if appropriately managed, is viewed as a major component of the water resources supply to meet the needs of a growing economy [3], [4], [5]. The reuse of treated municipal wastewater for purposes such as agricultural and landscape irrigation reduces the amount of water that needs to be extracted from natural water sources as well as reducing discharge of wastewater to the environment, specially in the Mediterranean countries and other arid and semi arid regions which are confronting increasing water shortages. During 1950-60, interests in applying wastewater on land in the western hemisphere as wastewater treatment technology advanced and quality of treated effluents steadfastly improved. Land application became a cost effective alternative of discharging effluent into surface water bodies [6]. In the United States, for example, it was reported that in 1995 the reuse of recycled wastewater approached 3.85 million cubic meters of which 2.72 million cubic meters were reused in irrigating agricultural crops. This amount of reclaimed water reuse for 1995 in the United States represented an increase of 36% from 1990 [7]. In Pakistan 26% of national vegetable production is irrigated with wastewater [8]. In Hanoi 80% of vegetable production is from urban and pre-urban areas [9]. In Ghana, informal irrigation involving diluted wastewater from rivers and streams occurs on an estimated 11500hectare, an area larger than the reported extent of formal irrigation in the country [10]. In Mexico about 260000hectare are irrigated with wastewater, mostly untreated, 4.25 m^3/s is reused for urban uses (filling recreational lakes, irrigating green areas, car washing), 3.2 m^3/s is used for filling a part of a dry lake called Texcoco, and for other local uses, and 45 m^3/s is transported 65 kilometers to the Mezquital Valley for irrigation. The reuse of this wastewater for irrigation represents an opportunity for the development of one of the most productive irrigation districts in the country [11]. In 2000, it was reported by the Palestinian water Authority that the total expected treated effluent that would be available for irrigating agricultural crops would reach 92 million cubic meters in 2020 and it expected that 70% of its agricultural water demand in 2040 will be met by treated wastewater [12]. Figure (1) shows the predicted increasing trends in reusing treated effluent in irrigation in Palestine. Kuwait has been practicing water reclamation and reuse for over 20 years as a means of extending its limited natural water supply, while the use of reclaimed water for landscape irrigation is growing in urban areas, the main reuse application is agricultural irrigation (4470 hectares or 11046 acres in 1997), representing 25 percent of the total irrigated area, reclaimed water is only allowed for the irrigation of vegetables eaten cooked (potatoes and cauliflower), industrial crops, forage crops (alfalfa and barley), and irrigation of highway landscapes [13]. Hyderabad, India, the capital city of Andhra Pradesh, is the fifth largest and the fastest growing city in India with 6 million inhabitants, the city produces over 700000m^3 of wastewater per day, of which less than 4 percent receives secondary treatment. The remaining 95 percent of the wastewater is disposed, untreated in the Musi River. The Musi River is the main source of irrigation water for over 40000hectare of agricultural land. Downstream of Hyderabad, the Musi River water is diverted through a system of weirs into irrigation canals is shown in figure (2) that were originally designed to retain water for the dry season after the monsoon rain [14].

In Iraq, the city of Baghdad for example produces large quantity of wastewater every day, most of it connected to sewerage system and then conveyed and received primary and secondary treatment, the rest disposed to the Tigris river without any treatment, and the using of treated wastewater for irrigation is still not experienced yet, table (1) [15].

GRAY WATER REUSE

Residential and industrial wastewater is normally produced continuously throughout the year, therefore, residential wastewater can be divided into black water (BW) and gray water (GW). The wastewater defines black water as wastewater discharged from, 1) Food preparation sinks (kitchen sinks) investigations indicated that kitchen gray water was highly polluting, and contains many undesirable compounds (e.g., cooking oils), Since this water accounts for only about 5% of the "average" household consumption, its use as a gray water source is almost negligible and not recommended. 2) Black water from toilets use around 20% of the total household water, wastewater derived from toilets is highly contaminated and can only be discharged to an approved sewerage system. With water reuse gaining popularity, people increasingly consider gray water from their residences as a resource to be separated from the wastewater stream and reused in their landscapes. Such reuse of gray water reduces the amount of wastewater entering sewers or individual wastewater systems (IWS), reduces demands to use potable water for other residential uses like irrigation, and helps to save limited water supplies for necessary uses like human consumption.

However, it must also be recognized that domestic gray water can be highly variable in composition, being heavily dependent on the dynamics and behavior of the households' occupants, and thus reflecting the inhabitants' age distribution, lifestyles, water use tendencies, and consumer choices (e.g. choice of cleaning and personal care products, choice of shower head etc.). The different gray water fractions (i.e. bathroom, laundry and kitchen grey water) also vary in composition as shows in table(2) for examples of published values for standard water quality parameters, with different plumbing fixtures (shower, dishwasher, kitchen sink etc.) not only generating different quantities of wastewater, but also differing in terms of characteristic pollutant sources and loads **[16].**

FEASIBILITY OF WASTEWATER USE IN IRAQ

In studying the feasibility of irrigation with wastewater, only the costs and benefits directly attributable to the use of wastewater should be considered. Thus, wastewater irrigation probably will not be financially or economically attractive where sufficient rainfall makes irrigation itself unattractive, because of the marginal increase in productivity would have to offset the entire cost of an irrigation system. On the other hand, where an irrigation system already exists, or where the demand for irrigation water exceeds the supply, the marginal cost of adding the wastewater (including treatment) may be justified by increased productivity **[17].**

In Iraq the north territories may be considered as a semi arid zone to arid, and reusing treated wastewater still to be justified due to the shortage in fresh water. The hilly and mountainous topography, therefore, requires more conveniently to use modern subsurface drip irrigation which is the best among other methods of irrigation for using treated wastewater. In the middle and south region of Iraq the shortage in fresh water is getting worse and the climate can be described hot and dry and typical arid area. Therefore, measures have to be taken toward using treated wastewater. Most (Probably all) of the Middle East countries have shown that this technology had proven its feasibility in the related concerns. As an alternative, irrigation with wastewater could be an attractive wastewater disposal option (called land application) in a situation where a high degree of treatment prior to discharge is required for environmental considerations.

DIRECT USE OF UNTREATED WASTEWATER

In contrast to planned reuse of treated wastewater, in developing countries especially when water is scarce, it is common practice to use wastewater directly, even without prior treatment, from a sewerage system or other purpose built wastewater conveyance system, or from storm water drains that carry large sewage flows. The wastewater is directed to plots via a formal irrigation canal system as in Haroonabad, Pakistan, figure (3) **[14]**, where it is used for vegetable production **[18]**. It may be extracted and used individually by many informal irrigators as in Nairobi, Kenya or Accra, Ghana, where farmers block or break sewers, deliberately causing them to overflow, so they can direct the wastewater to their plots. The direct use of untreated wastewater and in some instances fecal sludge from septic tanks, occurs in many parts of the world and has been reported from various countries in Asia, Africa, Latin America, and Mena region **[19]**. The chemical and physical quality of gray water compared with raw sewage is shown in table (3), the high variability of the gray water quality is due to factors such as source of water, water use efficiencies of appliances and fixtures, individual habits, products used (soaps, shampoos, detergents) and other site specific characteristics**[20]**.

INDIRECT USE OF UNTREATED WASTEWATER

This can be described as the application to land of usually dilute wastewater from a receiving water body. This situation is common in Iraq and other developing countries where municipal and industrial wastewater is discharged without treatment or control into the watercourses draining an urban area. The actual quality depends on:

1- The type of wastewater.
2- The degree of dilution.
3- The distance from the polluting source

As a consequence, many farmers indirectly use marginal quality water of unknown composition drawn from many points downstream of the urban centre **[21]**. In general, they are aware of the low quality of the water but lack the understanding of risks related to such activity, and in particular the knowledge about contamination pathways.

There are many examples of direct and indirect use of untreated wastewater in developing countries across the globe where in most cases this is a reflection of the inadequate nature of waste disposal practices, for example, despite massive investments in wastewater treatment, the city of Baghdad is not able to treat the wastewater generated, and untreated wastewater is discharged to waterways which are used downstream by farmers.

GENERAL REQUIREMENTS AND WASTEWATER TREATMENT ASSESSMENT

According to **[22]**, the safe and effective use of gray water, when black water cannot come in contact with gray water. As such, the wastewater streams must be separated by using two separate wastewater piping systems within the dwelling. The average house (based on 3 persons per house) uses approximately 1000 liters each day. This amount will vary according to the water use practices of the household and the various percentages are shown in figure (4) **[23]**. The two separate wastewater plumbing systems should then run into the appropriate disposal systems county sewer system (CS) or individual wastewater treatment system (IWS) for the black water and the collection tank for the gray water. Figure (5) is a house diagram of separate black water and gray water plumbing systems **[22]**. Black water can be treated with an individual wastewater system or diverted to an available sewer system. Once separated, gray water can be diverted for reuse, such as for landscape irrigation, or it can be directed to an IWS/CS. Diverted plumbing systems require separate management of black water and gray water sources. Because gray water systems may be used seasonally, it may need periodic maintenance, or may be abandoned in the future, a diversion valve should be placed in the gray water collection line at the point where it leaves the residence, figure (6). This diversion valves allows gray water flow to be directed to the gray water system or to be directed to the IWS/CS. If a residence is connected to the county sewer, the diversion valve will direct gray water either to the gray water system or to the county sewer system. Overflow from the gray water system must be diverted to the IWS/CS and a backwater valve must be installed. A backwater valve allows water to flow one way to the IWS/CS but prevents black water from backing up into the gray water system. Water flowing to the desired direction has enough pressure to lift the flap of the backwater valve and pass through it, but black water flowing the wrong way forces the flap to stay closed gray water can be collected, treated, stored and reused **[22]**. The type of wastewater treatment system chosen depends on the constituents present in the gray water and on the level of treatment desired, in some cases, a holding tank with a gravity fed pipe to the distribution system may be adequate.

WASTEWATER TREATMENT IN IRAQ

In Iraq, generally, the techniques used for wastewater treatment is conventional biological treatment which is currently used in old Al-Rustamiya treatment plant/ third extension and Al-Bueitha treatment plant.

Wastewater Treatment in Baghdad

The brief description of each treatment plant and the characteristics of waste are below**:**

Al-Rustamiya Treatment Plant /Third Extension

The design capacity of Al-Rustamiya Treatment Plant /Third Extension was 300000m^3/day and it is reach to be 900000m^3/day during rain seasons. The effluent released during summer and winter may vary from 450000 m^3/day to 300000m^3/day respectively. The characteristics of wastewater in Al-Rustaimya Treatment Plant/Third Extension are shown in table (5). Table (5) shown a considerable variation between the concentration in BOD, COD, SS in crude and final stage, this is due to treatment process, another variation in concentration at the same level crude (C) because of the type of water used (washing, domestic use, industrial use,..)[24].

Old Al-Rustamiya Treatment Plant

The design capacity of Old Al-Rustaimya treatment plant was 175000m^3/day, and it may reach up to 200000m^3/day during rainy season**.** The treatment plant is divided into two stages they refer to a first stage (0-1) (which in terms is divided in two symmetric stages), and the second one is stage(2)**,** The two stages are usually work together with a full capacity of 200000m^3/day. The characteristic of wastewater of the two stages of old Al-Rustimya treatment plant are shown in table(6) and table(7) respectively. Concerning value the of B.O.D in crude level, it was 220 p.p.m then and after treatment to the stage 0 (F0) & stage 1 (F1) the concentration falls to 17 & 13 respectively as shown in table (6). Also, by comparing the final results of treatment process of stages F0 & F1 shown in table (6) and table (7), it is obvious that the Rustaimya at stage F0 shows more efficient treatment than stage F1, this may attributed to periodic maintenances of the treatment plant in addition to the better standard of construction[24].

AL-Bueitha Wastewater Treatment plant

Concerning Al-Karkh (AL-Bueitha) plant, the treatment applied is not including chlorination process for security reasons. Moreover, this plant no longer working for the last six years, in addition there are no data available for this treatment plant, and currently wastewater inflow is disposed throw to the river (Tigris) without any treatment, knowing that design capacity of this treatment plant is 205000 m^3/ day.

FUTURE AMOUNT OF WASTEWATER IN THE CITY OF BAGHDAD

Currently the existing (WWTP) in Baghdad producing about (992000)m^3/day, if assuming the population of the city of Baghdad in 2011 is (8000000), on 2020 the population will become:.

$P_{2020}= 8000000\, e^{(0.022x\,9)}$

$P_{2020}= 9751699$

The amount of wastewater produced must be as much as (4388264) m^3/day if assuming that the usage 450l/c. day for the city of Baghdad, in terms of water reuse, this amount can irrigate about (43882)hectare.

ANALYSES OF WASTEWATER REUSE OPTIONS IN IRAQ

As the general trend of wastewater reuse worldwide is well defined, in Iraq, as in many Middle East countries, it can be possibly divided into two ways:-

A. Using treated wastewater from sewage treatment plant (STP).

B. Using treated gray water.

A. Using Treated Wastewater from (STP)

In Iraq using of treated wastewater for irrigation may be used for many purposes such as planting of recreation center, football yards, green areas, etc…

However, this should be associated with a proper management rules to regulate the operation of this new system and how to avoid negative effects on health and soil deterioration.

Opportunities for water reuse in road care and maintenance applications include street cleaning, reclaimed water for dust control and street cleaning is transferred to a truck at a fill station typically located at the water reclamation plant as shown in figure (7). In Iraq many car wash stations are installed each year, each wash can consume approximately 150 liters of potable water per car, and most of these car washes do not have a water cleaning or filtering system so that this amount of water could be reused by adding underground storage tank and connect the effluent to irrigation system as shown in figure (8).

B. Gray Water Reuse

The using of treated gray water is more reliable and economical than using treated wastewater, but proper management required to separate gray water from sewage wastewater at the source. It is easy to realize that, in Iraq, such a new technique cannot be applied suddenly as a replacement to existing old system, however, gradual steps may be taken starting with new residential complexes administrative buildings, and new government establishments.

CONCLUSIONS

Since the current technology of wastewater reuse is not used yet in Iraq, then it is difficult to discriminate between what might be considered as conclusions or to be recommendations. Anyway, the following points might be emphasized on as conclusions rather than recommendations:-

- As a planning concern, installing many wastewater treatment plants (WWTP) to serve separate area by using the meaning of "decentralization" shall afford easy operation and maintenance and decrease the cost to transport the treated water to landscape. This seems compatible with the fact that wastewater is generated increasingly due to population growth everywhere
- Public education to ensure awareness of the technology of recycled wastewater and its benefits is an important tool to guarantee the success of such a new system.
- Connecting the individual wastewater treatment plants together shall face efficiently the over flow season and will ensure that plants shall work together normally, knowing the fact that in Iraq wastewater treatment plants are not connected together, as a result, the efficiency of WWTP may be described low.
- Periodic measurements and necessary tests for the soils and plants have to be done when treated wastewater is to be used to ensure acceptable levels of heavy metal and salinity within allowable range.
- Soil leaching with fresh water is preferable to some extend when using treated wastewater since this will reduce the accumulation of salts and organic matter in the soil.
- Storage of treated wastewater for long time shall encourage the bacteria to grow up again causing bad impact on human due to direct contact.
- Disposing untreated wastewater to the natural sources is highly dangerous, unfortunately it is the case experienced now in most treatment plants in Baghdad due to bad maintenance and poor management.
- Isolation of industrial effluents from municipal wastewater to reduce the most harmful wastewater components is not being used in Iraq despite of some related legislation have been introduced.
- The abilities of using treated wastewater for firefighting is another practices which has been successfully used worldwide, and there are no limitations to use it in Iraq if some simple installations are adopted.
- Locally, the pioneer project which has been carried out in Iraq is the so called " Baghdad Green Belt project". This work has been designed with full documents for "Baghdad Mayoralty" "Amanat Baghdad" as client, and designed by "The Scientific Engineering Consultancy Bureau of the university of Technology" as consultant. In this project treated wastewater is to be used for irrigation to the first time in Iraq. Subsurface drip irrigation system is implemented with full automated operation. Contraction of the first part of the project has already started.

RECOMMENDATIONS

Among the many points that the new technology of water reuse consists, the following most important recommendation may be selected as appropriate.

- The using of treated wastewater should be in the range of allowable limits, especially in Iraq where such technique is not implemented yet, that is, to avoid devastating results on the soils, plants and environmental and public health.

- Policies must be implemented in Iraq to encourage pioneer farmers and traders to irrigate their field with treated wastewater as possible.
- Using of treated wastewater for irrigating ornamentals, as start, till a special legislation to protect the labor and consumers, is recommended.
- Separate system installations for collecting black and gray water separately is recommended to start with in Iraq, especially for new project of public sector developments and residential complexes.
- Industry should be encouraged to pretreatment their waste before discharging. Moreover, tighter monitoring, as well as, enforcement of harsh industrial effluent standards accompanied by financial charges to be imposed when disposing of untreated waste. This is likely to encourage enterprise to reduce their rate of disposes by adopting more environmentally friendly technologies in all their processes.
- New organizations institution and development projects should not be constructed unless permitted by the authorized office to ensure the ability to treat the effluent with the allowable limits before disposing it to the river.

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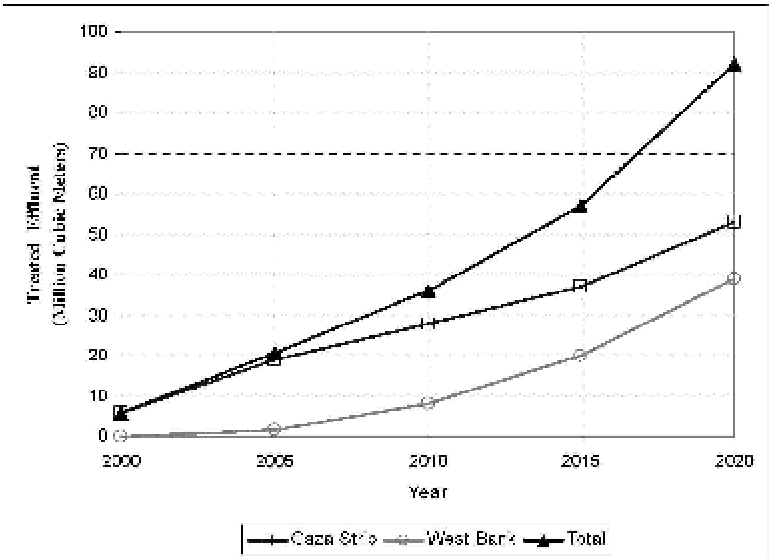

Figure (1) Predicted increasing trends in reusing treated Effluent in irrigation in Palestine.

Figure (2) Hyderabad, India–95 percent of the waste water is disposed untreated in the Musi River, wastewater being diverted over weir into irrigation canals.

Table (1) the average volumes of reclaimed water produced in several countries.

***Note*: (-) indicates that data was not available**

Country	Total Annual Water Withdrawal			Annual Reclaimed Water Usage			Reclaimed Water as Percent of Total
	Year	Mm3	MG	Year	Mm3	MG	
Algeria	1990	4,500	1,188,900	-	-	-	-
Bahrain	1991	239	63,144	1991	15	3,963	6%
Cyprus	1993	211	55,746	1997	23	6,077	11%
Egypt	1993	55,100	14,557,420	2000	700	184,940	1%
Iran	2001	81,000	21,400,200	1999	154	40,687	0.20%
Iraq	1990	42,800	11,307,760	-	-	-	-
Israel	1995	2,000	528,400	1995	200	52,840	10%
Jordan	1993	984	259,973	1997	58	15,324	6%
Kuwait	1994	538	142,140	1997	80	21,136	15%
Kyrgyzstan	1990	11,036	2,915,711	1994	0.14	37	0%
Lebanon	1994	1,293	341,611	1997	2	528	0.20%
Libya	1994	4,600	1,215,320	1999	40	10,568	1%
Morocco	1991	11,045	2,918,089	1994	38	10,040	0.30%
Oman	1991	1,223	323,117	1995	26	6,869	2%
Qatar	1994	285	75,297	1994	25	6,605	9%
Saudi Arabia	1992	17,018	4,496,156	2000	217	57,331	1%
Syria	1993	14,410	3,807,122	2000	370	97,754	3%
Tajikistan	1989	12,600	3,328,920	-	-	-	-
Tunisia	1990	3,075	812,415	1998	28	7,398	1%
Turkey	1992	31,600	8,348,720	2000	50	13,210	0%
Turkmenistan	1989	22,800	6,023,760	-	-	-	-
U. A. Emirates	1995	2,108	556,934	1999	185	48,877	9%
Yemen	1990	2,932	774,634	2000	6	1,585	0%

Table (2) General characteristics of gray water from Different household sources.

Chemical/physical property	Bathroom	Laundry	Kitchen	Mixed gray water
pH	6.4–8.6	8.1–10		5–8.7
TSS (mg l^{-1})	7-207	120-280	235-720	15-112
BOD (mg l^{-1})	26-300	48-380	47-1460	41-500
COD (mg l^{-1})	100-633	725-1815	644-1380	283-549
Total N (mg l^{-1})	3.6-17	6-21	40-74	0.6-11
Total P (mg l^{-1})	0.1->49	0.1->101	68-74	0.6->68

Figure(3) Lahore, Pakistan- Farmers installing a pump into a wastewater drain to draw water for irrigation.

Table (3) Typical Composition of Gray water compared with Raw Sewage

Parameter	Unit	Gray water		Raw sewage
		Range	Mean	
Suspended Solids	mg/L	45 – 330	115	100-500
Turbidity	NTU	22 – >200	100	NA
BOD5	mg/L	90 – 290	160	100 – 500
Nitrite	mg/L	<0.1 – 0.8	0.3	1-10
Ammonia	mg/L	<1.0 – 25.4	5.3	10-30
Total Kjeldahl Nitrogen	mg/L	2.1 – 31.5	12	20-80
Total Phosphorous	mg/L	0.6 – 27.3	8	5-30
Sulphate	mg/L	7.9 – 110	35	25-100
pH		6.6 – 8.7	7.5	6.5 – 8.5
Conductivity	mS/cm	325 –1140	600	300-800
Hardness (Ca & Mg)	mg/L	15-55	70	70-30
Sodium	mg/L	29-230	70	70-300

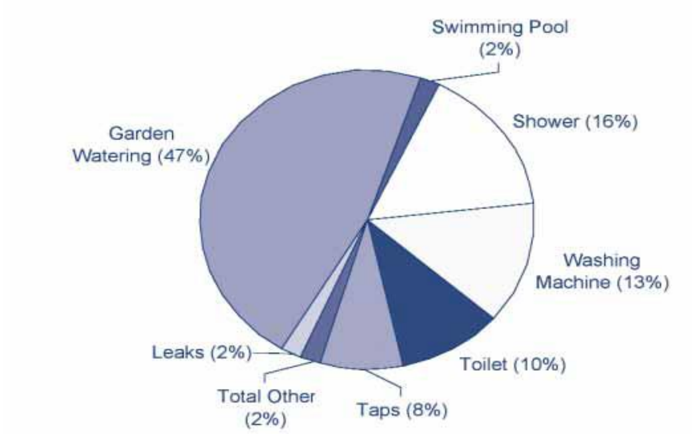

Figure (4) Household Water Usage.

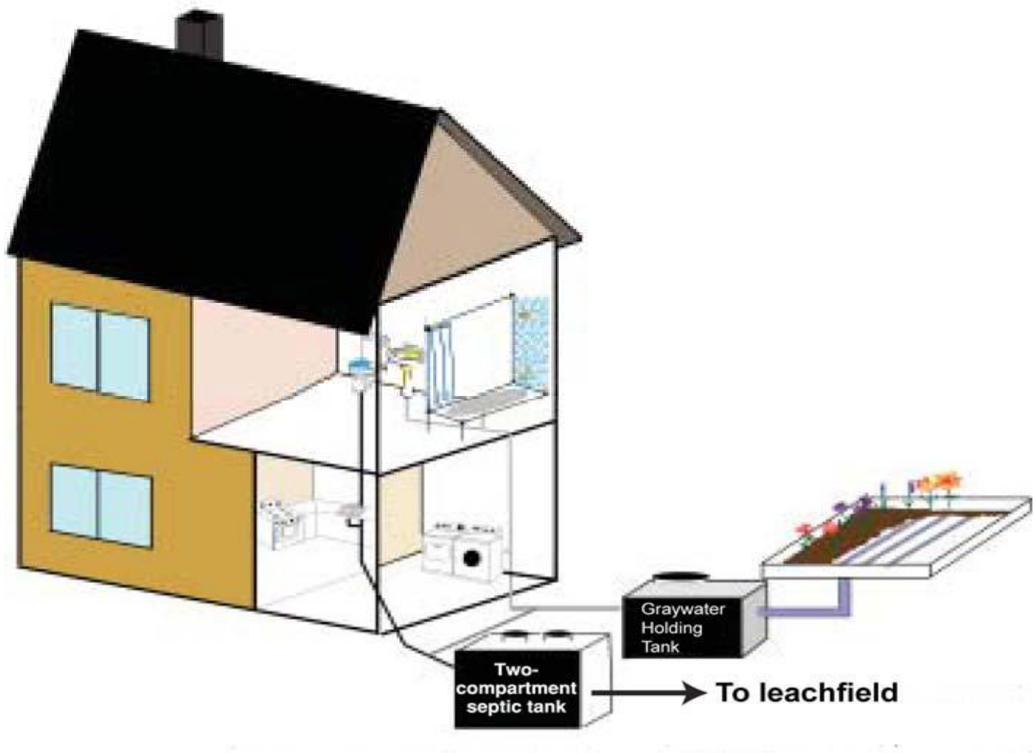

Figure (5) House diagram of separate black water and gray water plumbing systems.

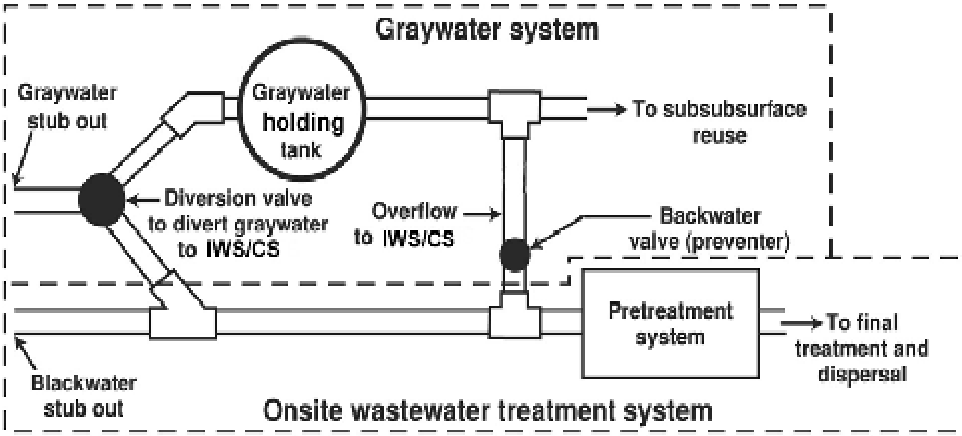

Figure (6) Diverted gray water plumbing system

Table (5) Characteristics of wastewater in Al-Rustaimya Treatment Plant /Third Extension, in winter.

Date	B.O.D ppm		C.O.D ppm		S.S ppm		PH		CL	
	C	F	C	F	C	F	C	F	C	F
2010-2-1	260	30	325	40	294	48	7.12	7.35	N/A	N/
2010-2-2	180	27	400	37	185	33	7.01	7.35		
2010-2-3	260	23	600	77	528	33	7.00	7.44		
2010-2-4	160	22	552	66	553	24	7.01	7.48		
2010-2-7	180	12	400	60	272	25	7.08	7.46		
2010-2-10	140	13	610	41	368	23	7.02	7.32		
2010-2-11	170	17	623	60	676	44	7.00	7.50		
2010-2-16	420	26	531	62	345	45	6.69	7.40		
2010-2-18	240	21	399	64	255	34	6.98	7.44		
2010-2-21	300	12	443	25	243	19	6.96	7.45		
2010-2-25	160	19	398	20	267	27	7.02	7.41		

Table (6) Old Characteristic of Al-Rustaimya wastewater plant, stage (0-1)

Tests	*BOD ppm*			*COD ppm*			*SS ppm*			*PH*			*Chloride*		
Sample	C*	F0	F1	C	F0	F1	C	F0	F1	C	F0	F1	C	F0	F1
Standers	**40**			**100**			**60**			**6.5-8.5**			**600**		
1/07/2010	**220**	**13**	**17**	**292**	**18**	**21**	**237**	**5**	**10**	**7.35**	**7.38**	**7.42**	**356**	**276**	**288**
4/07/2010	**280**	**11**	**14**	**322**	**36**	**41**	**170**	**33**	**29**	**7.38**	**7.42**	**7.33**	**356**	**264**	**260**
5/07/2010	**210**	**17**	**12**	**589**	**40**	**32**	**296**	**28**	**15**	**6.97**	**7.40**	**7.18**	**364**	**296**	**284**
6/07/2010	**390**	**19**	**21**	**246**	**32**	**38**	**399**	**41**	**29**	**7.26**	**7.43**	**7.30**	**300**	**218**	**198**
7/07/2010	**240**	**11**	**17**	**323**	**31**	**42**	**286**	**37**	**26**	**7.18**	**7.29**	**7.42**	**376**	**292**	**276**

11/07/2010	**320**	**37**	**16**	**514**	**88**	**61**	**439**	**63**	**50**	**7.1**	**7.23**	**7.25**	**364**	**276**	**284**
12/07/2010	**130**	**10**	**14**	**287**	**24**	**29**	**147**	**11**	**10**	**7.13**	**7.25**	**7.30**	**368**	**272**	**280**
13/07/2010	**560**	**14**	**16**	**316**	**31**	**42**	**154**	**14**	**15**	**7.15**	**7.30**	**7.41**	**360**	**212**	**210**
15/07/2010	**360**	**19**	**20**	**418**	**56**	**35**	**275**	**30**	**20**	**7.05**	**7.29**	**7.33**	**316**	**262**	**284**
18/07/2010	**218**	**11**	**23**	**327**	**43**	**47**	**154**	**28**	**45**	**7.20**	**7.11**	**7.33**	**372**	**284**	**276**
19/07/2010	**130**	**18**	**27**	**311**	**56**	**48**	**198**	**43**	**30**	**7.18**	**7.12**	**7.5**	**380**	**368**	**256**
20/07/2010	**180**	**	**12**	**298**	**	**33**	**156**	**	**36**	**6.88**	**	**7.43**	**368**	**	**280**
21/07/2010	**160**	**12**	**14**	**442**	**61**	**39**	**173**	**24**	**38**	**7.14**	**7.21**	**7.30**	**364**	**276**	**280**
22/07/2010	**300**	**16**	**17**	**316**	**44**	**51**	**202**	**35**	**22**	**7.01**	**7.52**	**7.40**	**360**	**272**	**268**
27/07/2010	**300**	**9**	**16**	**514**	**51**	**43**	**281**	**19**	**47**	**7.22**	**7.25**	**7.33**	**348**	**252**	**264**
28/07/2010	**130**	**9**	**14**	**372**	**33**	**37**	**231**	**38**	**43**	**7.00**	**7.20**	**7.30**	**320**	**248**	**244**
29/07/2010	**380**	**15**	**25**	**294**	**32**	**35**	**333**	**29**	**21**	**7.14**	**7.56**	**7.40**	**328**	**260**	**244**

C* = raw sewage F* = effluent
**= clean
Fo= Final effluent from stage (0) F1= Final effluent from stage (1)

Table (7) Old Characteristic of Al-Rustaimya wastewater plant, stage (2)

Testes	*BOD ppm*		*COD ppm*		*SS ppm*		*PH*		*Chloride*	
Sample	C*	F*	C	F	C	F	C	F	C	F
Standers	40		100		60		6.5-8.5		600	
1/07/2010	220	17	292	27	237	12	7.35	7.33	356	264
4/07/2010	280	16	322	52	170	32	7.38	7.1	356	248
5/07/2010	210	13	589	24	296	15	6.97	7.22	364	276
6/07/2010	390	15	246	42	399	13	7.26	7.53	300	202
7/07/2010	240	16	323	35	286	18	7.18	7.41	376	272
12/07/2010	130	13	287	44	147	17	7.13	7.22	368	284
13/07/2010	560	16	316	56	154	18	7.15	7.14	360	286
15/07/2010	360	22	418	41	275	29	7.05	7.26	316	280
18/07/2010	218	27	327	51	152	28	7.20	7.44	372	288
19/07/2010	130	24	311	44	198	28	7.18	7.32	380	280
20/07/2010	180	9	298	47	156	32	6.88	7.48	368	268
21/07/2010	160	16	442	53	173	41	7.14	7.43	364	272
22/07/2010	300	20	316	66	202	21	7.01	7.56	360	284
26/07/2010	380	18	324	31	598	26	7.09	7.23	300	210
27/07/2010	300	13	514	49	281	11	7.22	7.31	348	244
28/07/2010	130	11	372	38	231	22	7.00	7.12	320	268
29/07/2010	380	18	294	26	333	14	7.14	7.14	328	252

C* = raw sewage F* = effluent

Note: **All measurements and tests are done in Al-Rustaimya wastewater treatment plant laboratory**

Figure (7) Truck using reclaimed water to clean the street and control the dust

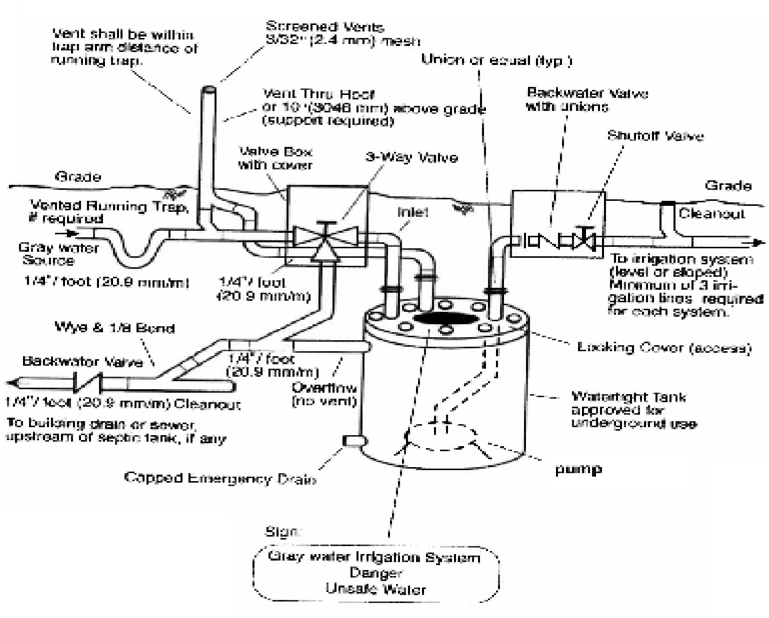

Figure (8) underground pumped system used for drip irrigation purposes.