Treatment and Reuse of Grey Water for Irrigation Using Plant and Sand Based Biofilters

Archana G S[1], Lokeshappa B[2] , Sreepathi L K[3]
[1, 2] Department of Civil Engineering
[3] Department of Mechanical Engineering
[1, 2] U.B.D.T. College of Engineering Davanagere, Karnataka, India
[3] JNN College of Engineering, Shimoga, Karnataka, India, India

Abstract- *The treatment and reuse of grey water for irrigation application is becoming a positive concern regarding conservation of water resources in recent days. The main aim of this work is to develop feasible treatment system that would allow economical and safe reuse of grey water for irrigation purpose. The system is mainly consists combination of plant based and sand based biofilters. The plant used for purification in this approach is Canna Indica and its removal efficiency is studied. The system is efficient in reducing unwanted salts like Total hardness, Calcium hardness, Magnesium hardness, conductivity, PH, turbidity, Chlorides, Sulphates, Carbonates, Bicarbonates, Sodium, Potassium, Sodium absorption ratio, residual sodium carbonates, soluble sodium percentage. The obtained values are within the discharge limits of irrigation water standards as per Indian society of soil science (ISSS). So that the treated effluent can be used safely for plants without any negative impacts.*

Keywords- Grey water; Plant based and Sand based biofilters; Canna indica; Irrigation water standards.

I. INTRODUCTION

Due to the increase in scarcity of water around the world, new water sources are developed. They are mainly (i) desalination of sea water. (ii) Surface water exploitation. (iii) Ground water sources. In these sources not only cost of usage is higher than the cost of conventional sources, but also they have very high adverse effect on environment. In order to overcome these adverse effects suitable measures should be taken to implement the non-conventional sources. For efficient utilization of urban water, on-site grey water reuse may play a significant role since it reduces urban water consumption.

A. Characteristics of Grey Water

Grey water is characterized as "All household sewage, except for wastewater created by toilets". Since the water appears to be cloudy and also from its status of neither being fresh nor highly polluted it is called as grey water [7][8]. Grey water is suitable for reuse even though it contains impurities like grease, hair and food particles. Reusing grey water will reduce the amount of freshwater supply to household and also reduces the amount of waste water entering septic tank or underground drainage. Treatment of waste water can be more effective if there is a separation of grey water and black water (toilet wastes). Grey water includes water from cooking, bathing, floor washing etc. Even grey water can affect the health and can also harm environment, since it is contaminated. Therefore, treatment and reuse of grey water should be done carefully without any adverse effect on environment and also it should be economical.

Grey water reuse may also cause health and environmental risk due to the presence of pathogens in it by direct contact or by mosquitoes. Addition to this it can also contain very high quantity of oils surfactants salts and boron which will be hazardous to the vegetation and ground water. Therefore both advantages as well as disadvantages need to be taken into account while designing grey water reuse policy. To implement grey water reuse scheme it should be simple to design and construct, economical, environmental friendly and also it should save time. The reuse of grey water for the purpose of toilet flushing and gardening can nearly save up to 50% of water consumption. Thus grey water reuse can reduce the weight on exhausted water resources while lessening water costs for residents and can also reduce the load on the central sewage system and treatment plants. Watering of garden can be done throughout the year, even in the time of drought.

B. Biofilters

It is found that, there are some plants which are acts like a biofilters. When grey water is fed into their root system, they can absorb the impurities and thereby treat the grey water. A grey water biofiltration system is a constructed wetland which eliminates a lot of poisons impurities from grey water before it streams into the groundwater, waterways, planting or any water systems. This framework can be constructed for a individual household or for a group of households. The system mainly involves in the phytoremediation phenomenon, can be defined as "The

method of purification where plants are involve to absorb, accumulate, detoxify and removal of contaminants from the surrounding soil, water and air through physical, chemical and biological processes". In order to emulate these features plants based biofilters are employed using plants like canna indica as filtering agent. It is commonly known as Indian shot which is a lasting developing to between 0.5 to 2.5 meters, depending upon the assortment. Its species can be utilized for the treatment of industrial waste water through development of wetlands. It is powerful for the expulsion of high organic load, colour and chlorinated natural mixes from wastewater

II. MATERIALS AND METHODOLOGY

A. Materials

The intended work consisting of mainly three sections that is collection tanks, plant based biofilter, biosand filter. Selection and preparation plant based biofilters and biosand filters is main task to enhance the treatment efficiency for treating and reusing of raw grey water for irrigation purpose. Poor selection and preparation of the filtration sand, plants, gravels could lead to low performance and a considerable treatment work to overcome the problem.The plant based biofilter and Biosand filter usually consisting of filter body, filtration sand layers and gravel layers.

1. Collection Tanks

The collection tanks are made up of plastic which are non reactive with the water so that the influent and effluent water quality can be maintained unaltered. The selected tanks should be free from any leakages or breakages and can hold required amount of water.

2. Filter Body

a. Plant Based Biofilter

The filter body of plant based biofilter can be made up of concrete, glass, plastic, stainless steel or any other water proof, rust proof or non toxic materials. Here the filter body is made up of plastic and filter media used is mainly contaminants absorbing plants like canna indica, which is generally called as Indian shot and having perennial growing nature. These plant roots are having capability of treating wastewaters by removing colouring dyes, organic contents and chlorinated organic elements. The wastewater like grey water mainly consisting of unwanted salts such as Nitrates, Sulphates, Boron, Phosphorous, Calcium, Magnesium etc. . . Which are main nutrients for plants for their growth and yield. When the wastewater is passed through the plant filter, plant roots absorbs unwanted salts, intern purifies that raw water.

b. Biosand Filter

Sand is a naturally available material which is granular in nature, containing of finely divided rock and mineral particles.

The selected sand should be free from any dirt, inert or biodegradable matters so that proper washing should be done. Proper crushed rock is a best kind of sand to enhance the treatment efficiency and also there are a less chances of contamination by pathogens and degradable contents.

The filtration takes place mechanically and biologically through this sand layers. Suspended matters get traps over sand layers mechanically. Trace organic matters are eaten by bacteria and protozoa, which are present in a sticky form over slime layer around sand particles.

In this filter, filtration sand is placed in three layers. The sand which passes through 1.18mm IS sieve and retained on 600micron IS sieve is placed in first layer, the sand which passes through 2.36mm IS sieve and retained on 1.18mm IS sieve is placed in second layer and in the third layer the sand which passes through 4.75mm IS sieve and retained on 2.36mm IS sieve is placed.

The gravel bed is prepared by selecting suitable gravels which are having properties like durable, angular and grain of dense nature. The main function of gravels in water treatment is uniform distribution of untreated influent over throughout the filter bed. When the influent water coming from the small or narrow area gravels spreads it into various branches and allow it to contact with whole filter bed. The gravel layer is a first filtrate in the biofilter to retain the particulate matters requires to be eliminating from influent waste water.

In this filter, the pebbles are placed in two layers. The pebbles which passes through 20mm IS sieve an retained on 10mm IS sieve is placed in first layer and the pebbles which passes through 40mm IS sieve and retained on 20mm IS sieve is placed in the second layer.

All the materials which are selected for filtration that is sand and gravel layers are sieved washed thoroughly and are oven dried for about 24 hours and then these materials are placed into the filter of a specified thickness.

B. Methodology

In order to carry out my research work I have collected domestic household grey wastewater sample and conducted laboratory tests to know the initial characteristics of wastewater. Depending upon the impurities present in the influent wastewater, locally available plant like canna indica, and filtrate sand and gravels are selected and the plant based biofilter and Biosand filter are prepared. Raw grey water is first passed through the plant based biofilter by providing continuous flow of 7 to 10 lts/hr and laboratory tests should be done to know the reduction of unwanted salts in influent water by plant roots , again it passes through sand biofilter. Treated water is collected and laboratory tests are conducted to know the reduction of impurities in the effluent water. Fig 2 shows that the methodology to treat raw Grey water.

Steps to be followed in the filter development and testing are

- Collection of raw grey water.
- Studying Initial characteristic of collected grey water sample.
- Treatment with the use of some locally available plants like cana indica.
- Treatment with Sand Biofilter
- Quality study for the treated grey water.
- Treated water quality comparision
- Reuse of treated water for irrigation
- Studying of feasibility of treated grey water for gardening and irrigational purpose

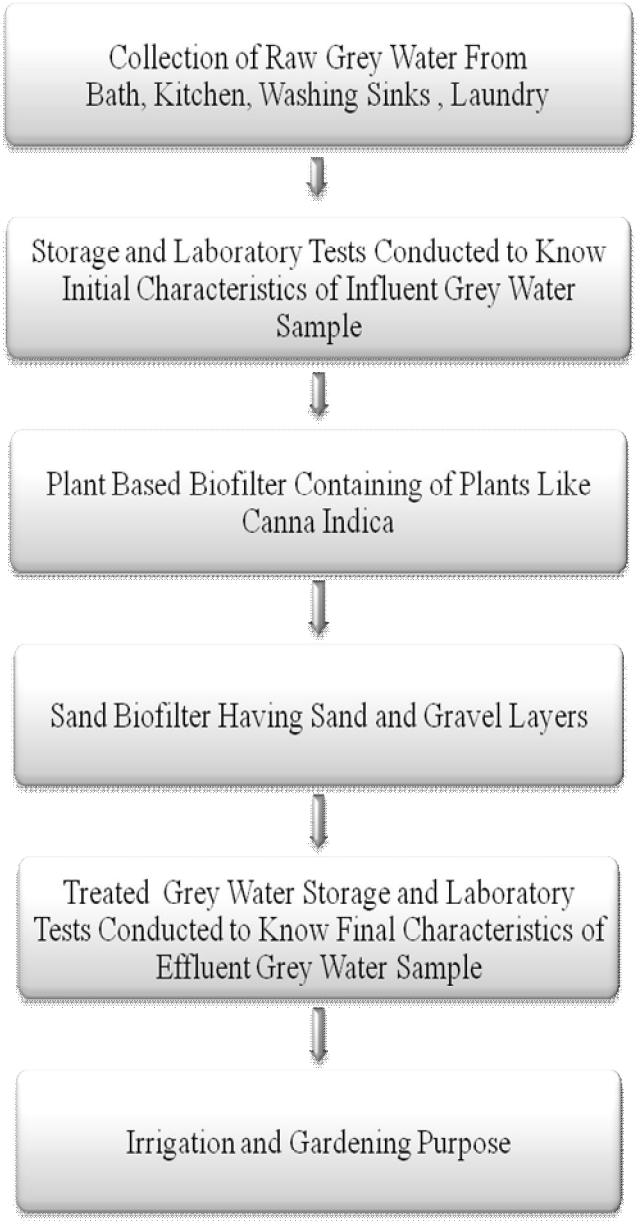

Figure 1. Flow Chart To Treat Raw Grey Water

a. Collection and Testing of Sample before Treatment

The Collected grey water from bathing, kitchen, laundry, hand wash sinks are stored in primary storage tank, grey water mainly contains bleaches, bath salts, artificial dyes, food waste, oil and grease, preservatives. Before treatment grey water is allowed to carry tests like, total hardness, calcium hardness, magnesium hardness, conductivity, pH, turbidity, chlorides, sulphates, carbonates, bicarbonates, sodium, potassium, sodium absorption ratio, residual sodium carbonates, soluble sodium percentage , in order to the know initial raw grey water characteristics. Fig 4 shows collection tank of raw grey water.

b. Biofilteration: (Plant Based Biofilter and Sand Biofilter)

The influent grey water is introduce to biofilters containing locally available plants like canna indica,sand and gravel layers. The grey water is allowed to flow continuously with flow rate of 7 to 10 lts/hr, which helps in absorbs the unwanted salts from water by the plant roots. Then the water from plant based biofilter is allowed to flow through sand biofilter where remaining trace contaminants and solids were removed.

c. Collection and Testing of Treated Sample

The treated water obtained from biofilters is again tested for parametrs like total hardness, calcium hardness, magnesium hardness, conductivity, pH, turbidity, chlorides, sulphates, carbonates, bicarbonates, sodium, potassium, sodium absorption ratio, residual sodium carbonates, soluble sodium percentage, by knowing the quality of effluent water, it can be used for irrigation purposes and other gardening usages. Fig 5 and Fig 6 shows collection and collected treated samples from plant based and sand based biofilter respectively.

d. Conduction of Laboratory Tests on Treated Water Samples

The collected raw grey water samples are subjected to laboratory tests like total hardness, calcium hardness, magnesium hardness, conductivity, pH, turbidity, chlorides, sulphates, carbonates, bicarbonates, sodium, potassium, sodium absorption ratio, residual sodium carbonates, soluble sodium percentage. The obtained results are compared with the Indian Society of Soil Science of irrigation water. It is observed that, obtained results are not under the desirable limits. Hence the water is subjected to purification and the impurities are removed from the raw grey water by introduced into filtration through plant based biofilter and biosand filter. Based on impurities present , the materials for purification purpose are selected such as plant like canna indica,which is well planted using suitable sand and soil ratio and sand , gravels layers, where these materials should be sieved using a set of sieves for grain size analysis. Following are the overview of the tests which are conducted

Parameters	Desirable limits	Raw Grey Water	Plant Filter	Biosand Filter
Total Hardness (mg/lt)	0 – 644	64.4	949.9	434.7
Conductivity (dS/m)	< 2.5	2.372	2	1.031
pH	6.5 - 8.4	8.79	7.11	7.73
Sulphates (mg/lt)	0 – 960	368.64	32.64	17.28
Chlorides (mg/lt)	71 – 177.5	1032.7	110.05	101.18
Sodium (mg/lt)	0 – 920	502.55	47.61	280.09
Carbonate (mg/lt)	0 – 30	12	0	0
Bicarbonates (mg/lt)	0 – 610	372.1	1287	579.5
Potassium (mg/lt)	0 – 78.2	19.9	97.4	64.9
SAR (meq/lts)	< 10	21.84	0.53	4.68
RSC (meq/lts)	< 1.25	4.1	0	0
SSP (meq/lts)	< 60	91.6	6.5	47.4

Table 1. Results and Discussions before and after treatment

III. RESULTS AND DISCUSSIONS

The collected raw grey water samples are subjected to laboratory tests like total hardness, calcium hardness, magnesium hardness, conductivity, pH, turbidity, chlorides, sulphates, carbonates, bicarbonates, sodium, potassium, sodium absorption ratio, residual sodium carbonates, soluble sodium percentage, before and after the filteration. The Table 1 shows that the results and discussions before and after treatment. From the proposed system of reusing the raw grey water for irrigational application using plant based biofilter with biosand filter, following conclusions are made.

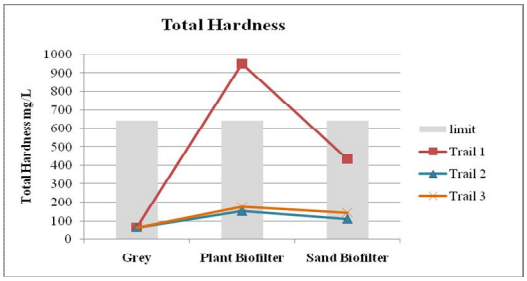

Figure 2. Variation of Total Hardness for 72 Hours with Respect to Greywater, Plant Biofilter , Sand Biofilter Respectively.

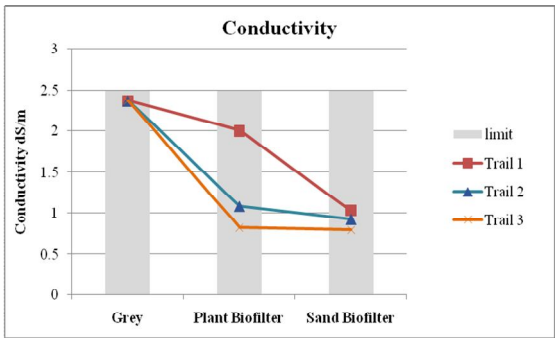

Figure 3. Variation of Electrical Conductivity or TDS for 72 Hours with Respect to Greywater, Plant Biofilter, Sand Biofilter Respectively.

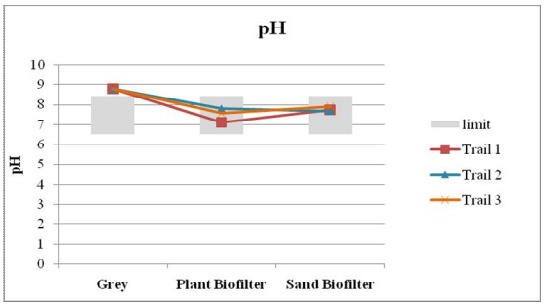

Figure 4. Variation of pH for 72 Hours Respect to Greywater, Plant Biofilter, Sand Biofilter Respectively.

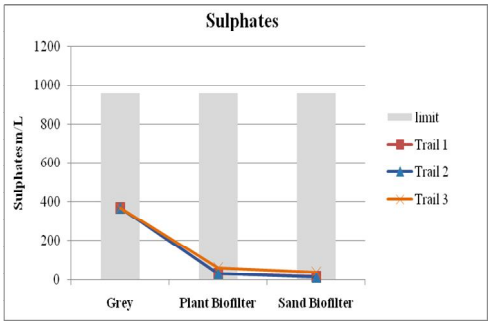

Figure 5Variation of Sulphates Concentration for 72 Hours with Respect to Greywater, Plant Biofilter, Sand Biofilter Respectively.

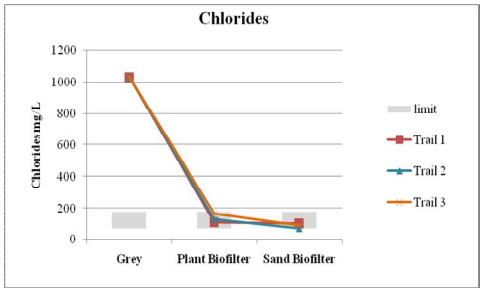

Figure 6. Variation of Chloride Concentration for 72 Hours with Respect to Greywater, Plant Biofilter, Sand Biofilter Respectively.

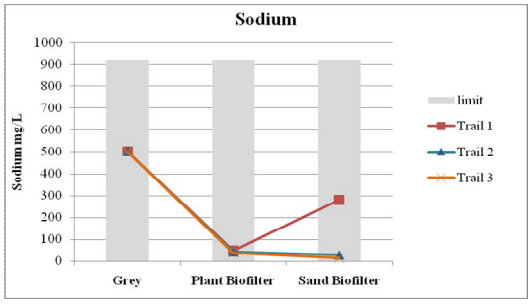

Figure 7. Variation of Sodium Concentration for 72 Hours with Respect to Greywater, Plant Biofilter, Sand Biofilter Respectively.

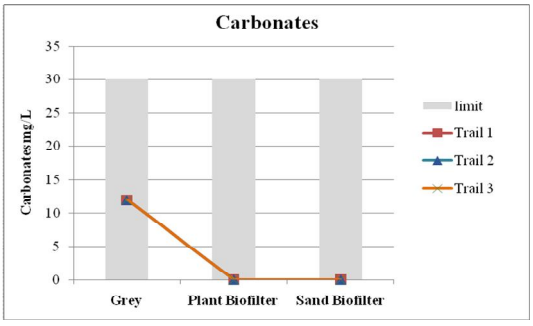

Figure 8. Variation of Carbonates Concentration for 72 Hours with Respect to Greywater, Plant Biofilter , Sand Biofilter Respectively.

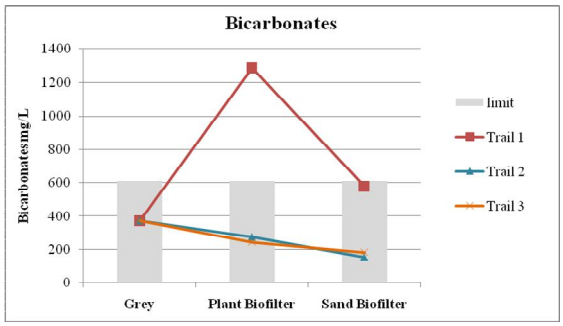

Figure 9. Variation of Bicarbonates Concentration for 72 Hours with Respect to Greywater ,Plant Biofilter, Sand Biofilter Respectively.

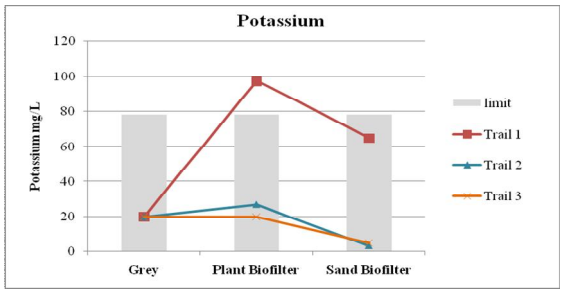

Figure 10. Variation of Potassium Concentration for 72 Hours with Respect Greywater, Plant Biofilter, Sand Biofilter Respectively.

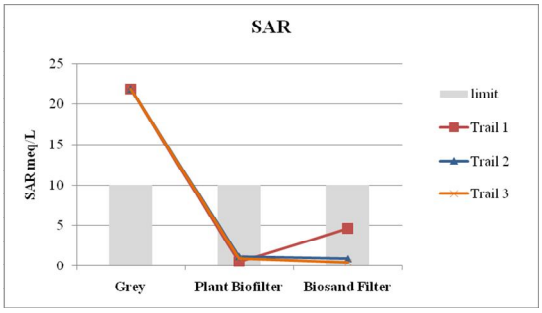

Figure 11.Variation of Sodium Absorption Ratio (SAR) for 72 Hours with Respect to Greywater, Plant Biofilter, Sand Biofilter Respectively.

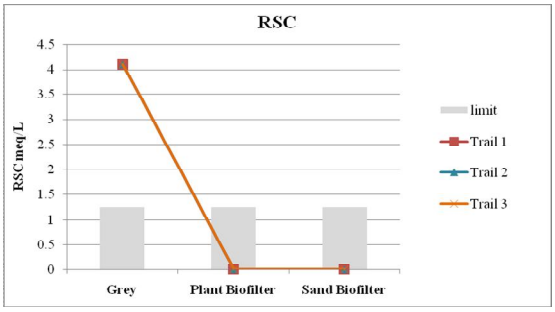

Figure 12. Variation of Residual Sodium Carbonate (RSC) for 72 Hours with Respect to Greywater, Plant Biofilter, Sand Biofilter Respectively.

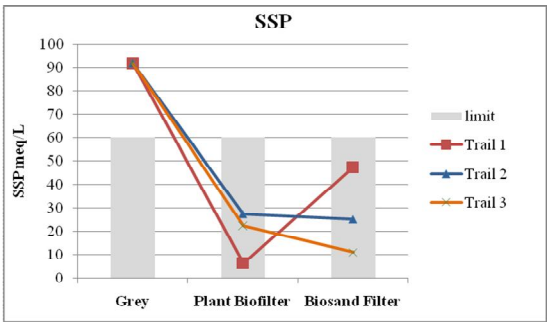

Figure 13. Variation of Soluble Sodium Percentage (SSP) for 72 Hours with Respect to Greywater, Plant Biofilter, Sand Biofilter Respectively.

IV. CONCLUSIONS

- Very low construction and maintenance cost, can be handled by unskilled labours.
- The proposed research work, combination of plant based Biofilter and Biosand filter is capable of complete removing of basic physical criteria like colour and odour , chemical issues like major trace elements that are consider for healthy growth of plants such as electrical conductivity, Sulphates, Sodium, Chlorides, Carbonates, Sodium absorption ratio, Residual sodium carbonates, and Soluble Sodium Percentage reduces about 57%, 96%, 44%, 91%, 100%, 79%, 100%, 44% in first trial, 61%, 96%, 94%, 93%, 100%, 99%, 100%, 97% in second trial, 66%, 89%, 98%, 92%, 100%, 99%, 100%, 95% in third trial respectively with the detention period of 72 hours.
- From the results conclude that all the chemical parameters like total hardness, calcium hardness, magnesium hardness, conductivity, pH, turbidity, chlorides, sulphates, carbonates, bicarbonates, sodium, potassium, sodium absorption ratio, residual sodium carbonates, soluble sodium percentage, required to meet the irrigation water standards are within the limits so that obtained treated effluent can be safely used for plants without any negative impact.
- The system can be made up of locally available plants and materials and without any chemical application for treatment, so that it is cost effective.
- The approach for reusing of raw Greywater, results in conservation of water resources without any negative impact on environment, so that it is eco-friendly.

REFERENCES

[1] Agency-UK, E., 2011. “Greywater for domestic users: an information guide”. Published by environmental agency.

[2] Al-Hamaiedeh, H., Bino, M., 2010. “Effect of treated grey water reuse in irrigation on soil and plants”. Desalination 256, 115-119.

[3] Al-Jayyousi, O.R., 2003. “Greywater reuse: towards sustainable water management”. Desalination 156, 181-192.

[4] Al-Mughalles, M.H., Rahman, R.A., Suja, F.B., Mahmud, M., Jalil, N., 2012. “Household greywater quantity and quality in Sana’a, Yemen”. EJGE 17, 1025-1034.

[5] Assayed, A., 2014. “Development of a new and innovative greywater treatment technique for urban agriculture: Drawer Compacted Sand Filter”, (Ph.D Dissertation), University of Surrey.

[6] Bani-Melhem, K., Al-Qodah, Z., Al-Shannag, M., Qasaimeh, A., Qtaishat, M.R., Alkasrawi, M., 2015. “On the performance of real grey water treatment using a submerged membrane bioreactor system”. Journal of Membrane Science 476, 40-49.

[7] Eriksson, E., Auffarth, K., Henze, M., Ledin, A., 2002. “Characteristics of Grey Wastewater”. Urban water. 4: 85-104.

[8] Jefferson, B., Palmer, A., Jeffrey, P., Stuetz, R., Judd, S.,

2004. “Greywater Characterisation and Its Impact on the Selection and Operation of Technologies for Urban Reuse”. Water Science and Technology. 50: 157-164.