

## ARTICLE

# Gray Water Measurement and Feasibility of Retrieval Using Innovative Technology and Application in Water Resources Management in Isfahan-Iran

Safieh Javadinejad<sup>1\*</sup> Rebwar Dara<sup>2</sup> Forough Jafary<sup>3</sup>

1. Isfahan University of Technology, Isfahan Province, Khomeyni Shahr, Daneshgah e Sanati Hwy, Iran
2. University of Salahaddin, Erbil, Iraq
3. University of Birmingham, Edgbaston St., B152TT, UK

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### ABSTRACT

Reuse of wastewater for agriculture and green spaces purposes is significant. A mean yearly precipitation in Esfahan is 150 mm. The drinking water and agriculture usually used underground resources in the city. Gray water recycling is known as a suitable option today. Delivering all the water requirements of a home from refined water rises the cost of water. Whereas the essential water quality for garden, toilet and irrigation is less than drinking water. Therefore, the aim of this study is to analyze the evaluation of gray water and estimate the amount of recycle gray water which can use for drinking water with innovation method in Esfahan region in Iran. Previous studies did not measure the value of recycling gray water with new method of waste water treatment that can use for drinking purpose. In this study, gray water in Esfahan city is measured and technical aspects of its recycling is examined. Because of the lack of referable guidelines and official technical reports, studies from other similar countries applied in this study and on the basis of which the amount of recoverable gray water was calculated. Evaluations indicates that the overall recovery of gray water in Esfahan saves nine million cubic meters of water. The price of the rial of this value established on water is 190 billion Rials. Given the lack of water sources in Esfahan, the recycle of gray water seems to be a good option, however more research is required to select a recovery strategy.

## 1. Introduction

Gray water refers to water used at home other than toilet waste<sup>[1]</sup>. Recovery and reuse of gray water, for non-drinking purposes, have a major role in reducing the consumption of purified water in urban areas<sup>[2]</sup>. This issue is described as one of the objectives of the green building and sustainable urban development

<sup>[3]</sup>. Sewage pollution from laundry, bath and shower is less than black wastewater from toilets<sup>[4]</sup>. Therefore, by collecting gray wastewater at one or more residential units and treating them in situ, it can be used as a suitable source of water for use. Indirect household use such as irrigation and toilet siphon<sup>[5]</sup>. But it should be noted that gray water is not completely safe<sup>[6]</sup>.

Wastewater recycling use in all of the world for dif-

\*Corresponding Author:

Safieh Javadinejad,

Isfahan University of Technology, Isfahan Province, Khomeyni Shahr, Daneshgah e Sanati Hwy, Iran;

Email: Javadinejad.safieh@pd.iut.ac.ir

ferent purposes includes increasing water availability, decreasing water scarcity and drought and increasing the sustainability of the environment and safety of public health<sup>[7]</sup>. Due to the continuous increase in the world's population, the water demand is increased and wastewater production is raised as well<sup>[8]</sup> and<sup>[9]</sup>. Therefore if wastewater can recycle, it can be a significant water supply especially for the regions that have scarcity in freshwater supply<sup>[10]</sup>.

Although recycling of wastewater can use for environmental and urban reuse, recreational and industrial purposes, it has a very important role in agricultural irrigation<sup>[11]</sup>. The possible resources for urban wastewater reuse are sewage, grey water (especially domestic wastewater excluding toilet flush) and rain water harvesting<sup>[12]</sup>.

Sometimes from the domestic section of the urban area, the rainwater and grey waters can mix and with recycle of these wastewaters it can use for the bathroom<sup>[13]</sup>. The advantage of recycling grey water is that it is significant source with a low organic content. The gray water includes up to 65% of total utilized water however contains only 30% of the organic and from 8 to 21% of the nutrients. By recycling gray water in domestic section the great value of water can use for toilet flushing and outdoor uses like garden watering and car washing<sup>[14]</sup>.

For instance in the UK, about 44% of water from shower, bath, hand basin, laundry and dishwasher contain gray water which can recycle. Also in larger scale it uses for irrigation of golf courses, parks, school yards, fire guard and air conditioning deliberated

### ***Treatment Technologies for Greywater Recycling***

Assessment of the treatment and recycling of grey water started since the 1970's<sup>[15]</sup>. The first technology which used for physical treatment included coarse filtration (sand filter) or membranes often combined with disinfection<sup>[16]</sup> and<sup>[17]</sup>. After that chemical treatments like electrocoagulation, conventional coagulation and photo-catalysis developed. The last technology based on biological method like rotating biological contactor, biological aerated filters<sup>[18]</sup> and<sup>[19]</sup>. In addition, innovative methods such as MBRs, reed beds and ponds have improved. Most of the methods use a screening or sedimentation stage before or after a disinfection stage (UV, chlorine). For example treatment of grey water can be done by using a rotating biological contactor headed through a sedimentation tank and tracked by UV disinfection.

Selecting a method with low cost and low maintenance especially for developing countries is very important. For example in Costa Rica and Jordan a low cost, low preservation system established and activated carbon, sand

filtration and disinfection for the treatment of water in a mosque is surveyed.

The quality of treated effluent for reuse for each region is different. Many countries have their own structures and controls based on controlling risk to human health, and establish the standards for microbial content like suspended solids (SS), biochemical oxygen demand (BOD), and turbidity<sup>[20]</sup> and<sup>[21]</sup>. Also, the aesthetics of the water that need to recycle play an important role<sup>[22]</sup>. If water reuse add in the regulations of water, it can effect on water quality parameters. Usually the mixture of biological systems and physical system is more convenience<sup>[23]</sup>.

The city of Isfahan has an estimated 4 million people in Iran in 2016. With a growth factor, the population of the city is currently estimated at 4.5 million. Water from Isfahan is provided through 150 deep wells. The city's water consumption is currently 75 thousand cubic meters per day. And in 2020, the amount of water consumed by the city will reach 150 thousand cubic meters. Therefore, the recovery of gray water can play an important role in protecting water resources.

One of the most significant alternative water supplies to manage with water shortage in Iran is treatment and reuse of domestic wastewater. Greywater (GW) contains approximately 60-70% of the total domestic wastewater created in houses in Isfahan in Iran. GW is a part of domestic wastewater, containing wastes of showers, baths, wash basins, laundry, and kitchen sinks. Consequently, with suitable reuse of GW, domestic potable water consumption would be declined. Treatment and reuse of GW approved through various countries because of its safety, health, and economic cost. Furthermore, GW has fewer pollution contrasted to the municipal wastewater and is therefore suitable for reuse. With appropriate treatment of this water, effluent may be applied for irrigation, flash tanks at toilets, and other consumptions. Since that Iran is an arid country with a rising population and limited water supplies, appropriate strategies should be taken into account for efficient use of supplies. Consequently, treatment and reuse of GW can recompense a part of water scarcity. Currently, various physical, chemical, and biological methods examined for GW treatment. Studies displayed that physical treatment systems for instance multimedia filtration and membrane procedures have good productivity in removal of solids, however do not have a decent productivity in removal of organic compounds. Suitable alternative to membrane procedures for instance Micro Filtration (MF), Ultra Filtration (UF), Nano Filtration (NF), and Reverse Osmosis (RO) is applying these procedures as a post treatment opportunity for GW treatment. Chemical procedures have suitable productivity in removal of organic matter,

suspended solids, and surfactants in GW; nevertheless, information on chemical treatment systems is very restricted; it is just recognized that these systems have very small hydraulic retention time their cost is too great. Thus, chemical biological or chemical-physical mixture techniques can be applied for GW treatment to decline the chemical techniques' costs. Biological treatment systems commonly have good productivity for removal of organic combinations in wastewater treatment. Integrated Fixed-film Activated Sludge (IFAS) as a biological treatment system is a combined procedure containing microorganisms with suspended and attached enlargement. This system has higher resistance to organic and hydraulic loading shock than conventional activated sludge. In this study, IFAS is discovered for GW treatment in 107 days.

## 2. Materials and Methods

The method that used in this study is combined method of physical, chemical and biological. So at first all these methods are explained in below:

### 2.1 Simple Treatment Systems

Simple technologies applied for grey water recycling are usually two-stage systems established on a coarse filtration or sedimentation stage to remove the larger solids followed by disinfection.

For example, in Western Australia<sup>[24]</sup> applied simple systems beside a coarse filter or a sedimentation tank. In Australia the regulation allows users to reuse gray water and apply simple treatment and then use the water for irrigation. There is a limitation to use the simple treatment technique regards to the value of organics and solids. So, this system is suitable for small scale like domestic purposes and it is a great remover for micro-organisms. With disinfection phase, the coliforms residuals can decrease to 50 cfu.100mL-1 in the treated sewages. The ability of this system to treat complicated wastewater of bath, shower and hand basin is low. In previous researches, there is limited information about the hydraulic implementation and hydraulic retention time (HRT). Only<sup>[25]</sup> considered an HRT of 38 hours for a large scale system (the room of one hotel in Spain). The simple treatment systems need very low operational cost. Therefore, in UK this system with a sedimentation tank, disinfection with sodium hypochlorite and two 300 µm nylon filters is using because the cost is only £50/year.

### 2.2 Chemical Treatment Systems

There are three methods for chemical treatment systems. Generally the system based on coagulation with alumi-

num. The first method is a mixture of sand filter, granular activated carbon (GAC) and coagulation for the treatment. The second method is a combination of electro-coagulation with disinfection for the treatment of a slight strength grey water. The third method can treat the grey water with BOD and suspended solids residuals of 9-23 mg.L-1, a turbidity residual of 4 NTU and invisible levels of E. Coli. Nonetheless, the source must have a really low organic power with a BOD concentration of 25 mg.L-1 in the raw grey water. Moreover, the hydraulic retention times in this system is around 20 and 40 minutes. The third method established on photo-catalytic oxidation with titanium dioxide and UV that can treat the wastewater in short time. Actually, with an HRT of 30 minutes, it can remove 90% of the organics and 6 log removal of the whole coliforms. The cost of this system is around £0.04/m<sup>3</sup>.

### 2.3 Physical Treatment Systems

Physical systems include sand filters and membranes. Sand filters can use alone or in combination with disinfection or with activated carbon and disinfection. In this system, sand filters create a coarse filtration of the grey water. Sand filters can provide the limited treatment of the various fractions present in the grey water.

<sup>[26]</sup> examined the treatment of kitchen sink water through a soil filter. The research reported that 68% remove for the BOD and 79% for suspended solids and residual concentrations was 166 mg.L-1. When the filter method mix with a disinfection phase, the removal of microorganisms will increase.

<sup>[27]</sup> analyzed the treatment of bath and laundry grey water through filter and chlorine disinfection and 47% of the turbidity and 16% of suspended solids removed. James *et al.* (2016) evaluated by this system the micro-organism can remove significantly and total coliform concentrations by the treated waste water ranges between 0 and 4 cfu.100mL-1.

<sup>[28]</sup> measured that hydraulic loading rates was 0.25 m<sup>3</sup>.m-2.d-1 via soil filtration. If multi-media filters with sand use for the treatment, the hydraulic loading rates range from 116 to 577 m<sup>3</sup>.m-2.d-1. With using pore size of the membrane in the system, the removal of the dissolved, suspended solids and turbidity will increase more than 90%. In addition the efficiency of COD removal can increase to 93%.

<sup>[29]</sup> used nano-filtration (NF) and pore size of the membrane for making the treatment of shower water.

Furthermore, <sup>[30]</sup> evaluated the usage of a UF membrane (0.06 µm pore size) and reverse osmosis (RO) membrane for treating the laundry wastewater. With this system 55% of the removal of BOD will increase.

About the removal of micro-organisms through membranes there is limited studies. Nonetheless, [31] evaluated that by this method 35% of coliforms and micro-organisms will remove. The disadvantage of this method is residual of sediment because of organic matter that cause increasing the cost of treatment for removing the sediment as well [32]. However, by increasing the efficiency of pre-treatment by using screening or sand filter this problem may solve. The performance of the mixture of pre-treatment, physical processes, sand filter, nano-filtration, membrane, and disinfection is very convenience and the value of BOD and turbidity will decrease.

## 2.4 Biological Treatment Systems

The processes of biological treatment systems include fixed film reactors rotating biological contactor, anaerobic filters, sequencing batch reactor, membrane Bioreactors and biological aerated filters (BAF).

## 2.5 Biological Treatment

Usually Biological systems mix with physical pre-treatment like sedimentation or screening, membranes in procedures like MBRs, sand filter, activated carbon and disinfection. This system usually can install in bigger buildings.

Hydraulic retention times (HRTs) estimated from 0.9 hours up to 2.9 days for the biological systems. There is limited information about solids retention time (SRT). However, organic loading rates range from 0.11 and 7.59 kg.m<sup>-3</sup>.day<sup>-1</sup> for COD and about 0.09 and 2.39 kg.m<sup>-3</sup>.day<sup>-1</sup> for BOD (Ramprasad *et al.* 2016). All turbidity and suspended solids residual could be below 15 mg.L<sup>-1</sup>.

Furthermore, as mentioned before, the MBRs can remove the organic and solid fractions with average residuals of 4 mg.L<sup>-2</sup> for BOD, 3 NTU for turbidity and 6 mg.L<sup>-1</sup> for suspended solids. Nonetheless, Jeong *et al.* (2018) expressed that at small scale, the variation in strength and flow of the grey water and potential shock loading influence on the performance of biological established technologies. Laine2 found the effect of domestic product spiking on biomass from an MBR and indicated that products like bleach, caustic soda, perfume, vegetable oil and washing powder were relatively toxic with EC50 of 2.5, 7, 20, 23 and 29 mL.L<sup>-1</sup> correspondingly. Furthermore, Jefferson *et al.* examined the reliability of a BAF and an MBR under intermittent process of air, feed and both. The functioning of the MBR did not effect by interruption of the feed, air or both as the time taken through the process to return to its original performance level was always very short (in fact no interruption in performance level was observed).

A similar output investigated while the feed ceased for 25 days. Nevertheless, in contrast, the BAF did not show the similar robustness. Even though short term interruptions (30 minutes) did not have an influence on the BAF functioning, longer cessation of the feed and/or air, generated a rise in the effluent concentrations and the recovery times for whole the elements. Also, afterward an interruption of the feed of 8 hours, the recovery times estimated 4, 4, 40 and 48 hours for turbidity, suspended solids, faecal coliforms and total coliforms correspondingly. Equally, after the same interruption of the air, the recovery times were 4, 4, 24, 28 and 24 hours for BOD, turbidity, solids, faecal coliforms and total coliforms correspondingly. The lengthiest recovery times measured after the interruption of both air and feed simultaneously with 40, 40, 4, 24, 48 hours for BOD, turbidity, solids, faecal coliforms and total coliforms correspondingly. In conclusion, none of the elements recovered to their pre-interruption levels within 48 hours of the interruption of the feed for 25 days. Again, restricted information is accessible about the prices of the systems. However a capital cost of £3,346 for the building and installation of a retro-fit system in a 40-student residence composed of a buffering tank with screening, an aerated biofilter, a deep bed filter and GAC can estimate. The O & M costs is about £129/year containing the energy, labour and consumables. Through water savings of £518/year, the pay back period is 7-8 years. They measured that if the system matched in a new building the capital cost might be declined to £1,720 and then the regulated pay back period would be 3-4 years. The system that represented by Mac *et al* include a screening filter, a treatment tank with bio-film grown on aggregate balls, a particle filter and UV disinfection unit installed in an individual house measured to cost among £2,514-£3,325. Otherwise, Bino indicated a low cost, easy to built system created of four plastic barrels installed in a 6- person house with a capital cost of £197. There is no information on the functioning costs and water savings for these two schemes. Normally, Finally, Gardner and Millar 63 reported a capital cost is £2,230 and O & M costs is £87/year for a system based on a septic tank, a sand filter and UV disinfection. Nevertheless, the water savings of (£34/year) is not sufficient to cover the costs.

In this study, the amount of water consumed in Isfahan city was calculated based on 10 years data of Isfahan Water and Wastewater Company. According to various scenarios, the estimated amount of gray water recovery was estimated based on the cost of water and waste treatment costs and the costs of designing the gray water separation system. The amount of water and sewage produced in Isfahan city over the past five years is shown in Table 1.



**Table 1.** Amount of wastewater and gray water in the study area

| Year | Water consumption | Wastewater | Gray water |
|------|-------------------|------------|------------|
| 2013 | 92511063          | 1885668    | 5285602    |
| 2014 | 10248899          | 2231000    | 5851043    |
| 2015 | 11025342          | 2377545    | 6347693    |
| 2016 | 11586069          | 2686373    | 6508773    |
| 2017 | 12562283          | 2933331    | 7071960    |

Then, with regard to the share of gray water, its value was estimated. And its economic value was calculated based on the price of water and the cost of wastewater treatment. In the following, due to the costs incurred by the implementation of the gray water recovery plan, several scenarios were considered and the feasibility of its implementation was evaluated economically and technically.

### 3. Results and Discussion

At present, the price of water is 10000 rials per cubic meter, and the cost of treatment for wastewater is about 5300 rials per cubic meter. Given the amount of gray water that can be retrieved, you can calculate the numerical value of raw saving. Of course, it should be noted that all gray water can not be recovered. Because the sources of gray water are varied and their quality is different ( Sievers et al. 2017). Gray water recovery is different depending on the type of treatment and equipment required. In this way, the cost of recovery must be calculated in the chosen method and, taking into account the costs associated with the recovery method and the expected savings, the recovery function can be economically calculated. The amount of produced gray water in terms of the source is shown in Table 2.

**Table 2.** Water using in domestic sector

| Type of wastewater | Wastewater |       | Gray water |       |
|--------------------|------------|-------|------------|-------|
|                    | Percentage | l/day | Percentage | l/day |
| Toilet             | 16         | 23    | -          | -     |
| Hand washing       | 6          | 8     | 8          | 8     |
| Bath               | 34         | 51    | 57         | 51    |
| Kitchen            | 11         | 16    | -          | -     |
| Washing machine    | 14         | 21    | 23         | 21    |
| Dish washer        | 11         | 16    | 18         | 16    |
| Cooler             | 4          | 5     | -          | -     |
| Cleaning           | 12         | 17    | -          | -     |

Due to the price of water, the price of water can be calculated. The numerical raw material for saving gray water is shown in Table 3.

**Table 3.** The price of water with recycling gray water

| Type of wastewater      | Average of yearly gray water |           | Million RLS per year |
|-------------------------|------------------------------|-----------|----------------------|
|                         | Percentage                   | M3/year   |                      |
| Toilet and hand washing | 6                            | 633115.16 | 1657.79              |
| Bath                    | 34                           | 4212553.5 | 10381.38             |
| Dish washer             | 11                           | 1347228.3 | 3116.57              |
| Landry machine          | 14                           | 1720097.8 | 4150.24              |

If we want to calculate the amount of household savings, we need to calculate the amount of gray water for each household. For this purpose, the percentage of gray water is multiplied by per capita consumption of water and household size. Considering the average per capita consumption of 150 liters per day as per capita and household size equal to 5, the amount of gray water water is calculated as follows (Table 4).

Gray water content (liters per year) = 365 \* Per capita water consumption per day \* 5 \*% gray water

**Table 4.** Amount of gray water recycling in each family

| Type of wastewater      | Average of yearly gray water |         | Million RLS per year |
|-------------------------|------------------------------|---------|----------------------|
|                         | Percentage                   | M3/year |                      |
| Toilet and hand washing | 6                            | 137.88  | 0.34                 |
| Bath                    | 34                           | 904.38  | 2.27                 |
| Dish washer             | 11                           | 274.75  | 0.69                 |
| Landry machine          | 14                           | 356.88  | 0.90                 |

As can be seen, taking into account the price per cubic meter of drinking water equivalent to 2500 Rials, the total amount of saving for a 5-person household is 4.17 million Rials. This can be higher due to the evolution of water consumption rates.

In this study, the burden of contamination of various sources of gray water has not been measured. But the review of studies shows that gray water has significant contamination. And in the case of non-scientific recovery it can be problematic.

If we consider the microbial contamination index to be the total fecal form, Table 5 lists the load of gray water pollution.

**Table 5.** Total coliform in gray water

| Source            | Kapisak     | Brands          | Clif        | Rose        |
|-------------------|-------------|-----------------|-------------|-------------|
| Bath              | 7 x 103 cfu | < 10 to 2 x 108 | 5 x 105 MPN | 7 x 103 cfu |
| Landry machine    |             |                 | 3 x 103-107 | 127 cfu     |
| Dryer machine     |             |                 |             | 26 cfu      |
| Kitchen           | 3 x 109     | 9 x 105         |             |             |
| Total composition | 1.74 x 105  | 13 x 106        |             | 6 to 80 cfu |

The amount of purification needed for each of the listed resources is also different and the cost associated with it will also be different. And in choosing a particular scenario, the cost of the preliminary purification of gray water and its management should also be considered.

So far, different strategies have been developed and tested by various countries. Among these strategies at the point of generating gray water, two general strategies can be mentioned:

(1) The maximum use of gray water and the design of a relatively expensive refining system

(2) Strategies for using gray water with low contamination with minimal purification possible

Of course, amongst these strategies, interstitial strategies can also be adopted. From the point of view of gray water point, two main strategies can be adopted.

(1) Use of gray water in the interior of the building

(2) Use of gray water in the outside space of the building

The amount of gray water pollution is considered and the peripheral needs such as pre-treatment, plumbing and safety and health considerations affect the adoption of waste water points. By summing up the main strategies and analyzing the cost, a specific strategy can be adopted based on an acceptable benchmark, such as national standards and wastewater disposal guidelines. This strategy varies from city to city, from building to building, and even from house to house. Because the final decision is regarding the recovery of gray water with the final consumer of water, residential buildings. And it will be different depending on whether the residential building is a villa, apartment and residential complex. Economic analysis shows that the use of sophisticated cleaning methods in villa houses and small apartments is not cost-effective.

One of the easiest ways to recover gray water is to return the inner water of the bathroom to the flash tank. Through this approach, about 7% of the water can be recovered, and 7% is saved through the water needed for the tank's flash. In addition, this method does not require much refinement. It can be done with a simple smoothing. The new system of gray water is showed in figure 1.



Figure 1. The new system and package for recycling gray water

There are many different types of gray water treatment systems in the world today. Gray water contains some suspended matter, detergent and microorganisms and should be purified before use. Table 6 shows the typical combination of gray water (Green, 2018).

Table 6. Comparison of water quality parameter in gray water and in waste water

| Parameter | Unit  | Graywater |          | Waste water |
|-----------|-------|-----------|----------|-------------|
|           |       | Average   | Range    |             |
| TSS       | mg/L  | 116       | 46-340   | 100-600     |
|           | NTU   | 101       | 23-203   | NA          |
| BOD       | mg/L  | 161       | 91-294   | 100-600     |
| TKN       | mg/L  | 13        | 2.2-32.5 | 30-80       |
| Phosphor  | mg/L  | 9         | 0.7-13   | 6-40        |
| EC        | mS/cm | 603       | 326-1141 | 400-900     |

Gray water purification can be a simple filter. Or use advanced methods such as MBR. Gray water should be cleaned and disinfected due to microbial load. Chemical detoxification is preferred to chlorine. But due to its environmental and safety aspects, ultraviolet radiation and ozone are recommended. In order to estimate the cost of recovering gray water, the economic value of other countries was used and localized [25]. The estimated cost of purifying and recovering gray water is a simple system in Table 7.

Table 7. Price of the system component for recycling gray water

| Case                            | Price based on an item | Unit                        | Formula         |
|---------------------------------|------------------------|-----------------------------|-----------------|
| Piping                          | Length                 | 1000RIs/m                   | C=60.L          |
| Storage tank                    | M3                     | 1000RIs/m <sup>3</sup>      | C=1400.V0.5     |
| Pump                            | Discharge              | 1000RIs/(m <sup>3</sup> /d) | C=6000.Q0.028   |
| System of waste water treatment | Discharge              | 1000RIs/(m <sup>3</sup> /d) | C=35900.Q0.6776 |
| CL                              | Special unit           | 1000RIs/unit                | 1500            |

Gray water recovery, besides the base cost, also costs another. Which should be considered in the economic analysis of gray water retrieval. These costs include the cost of management and operation, including required manpower, chemicals, energy consumption, possible repairs, etc. These costs are usually reduced by increasing the number of residential units in each apartment or residential complex Cook, (2016).

Experiences from other countries in using gray water indicate that, on average, 57% of household sewage can

be used as gray water. In this case, in addition to reducing the cost of saving water (reducing the cost of water consumed by 40%), the corresponding economic savings are remarkable.

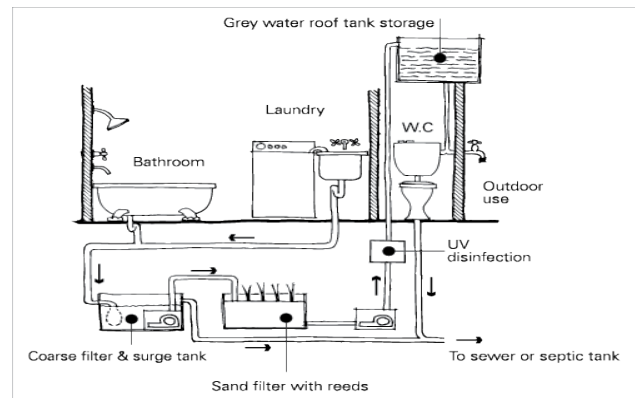
Iran is a dry and dehydrated country, which, due to population growth and limited water resources, should provide appropriate solutions for the optimal use of resources. Considering that most of the country is in low water and a significant population lives in these areas, modern methods of correct use and even reuse can be useful for the development of the above areas. As noted, using the experience of other countries, including (Middle Eastern countries), which they, like Iran, are facing with water scarcity, the use of gray water can be effective in solving the problems of dehydration. In addition, health aspects should be considered.

Considering that the average rainfall of Bojnourd is about 300 mm and every year there is a drought, the centralized collection of gray water in homes and the reuse of it in irrigating the green space makes it possible to minimize the environmental damage caused by droughts. Of course, in adopting a strategy for the recovery of gray water, health, technical, economic, cultural development and public education should be considered. And adopted a method that, while recovering the maximum water and wastewater, its health and technical aspects should be considered. According to the calculations, the recovery of all gray water in short-lived buildings does not have economic justification. But in high-rise buildings, economic justification is justified due to the cost of recovering and purifying the gray water. There are currently no clear guidelines on the acceptable quality of gray water. Therefore, definitive comments can not be made. But by looking at the experiences of other countries, the following scenarios are likely.

(1) Recovery of whole volume of gray water in concentrated form and in order to irrigate the green space: Perhaps the most ideal scenario is the recovery of all gray water, but the problems due to the cost of designing a separate collection system and minimum speed problems in the sewage collection networks Removes the option from the priority.

(2) Recovery of gray water at the place of production

① Green Gravel Water Recovery: This method provides significant savings in the water needed to irrigate the green space. But this method requires relatively sophisticated facilities, so that gray water is refined and reused by sub-surface irrigation systems, and its health aspects should be taken into account (Figure 2).



**Figure 2.** The new system of recycling gray water for using irrigation

② Recovering gray water from less polluted areas for non-drinking water requirements: In this way, some parts of gray water can be recovered for other residential uses. The most remarkable type of recovery in this method is the use of bath and bathroom drainage to flush the toilet tanks. This method, with its simplicity, needs little refinement and does not interfere with the sewage collection system. Because the water is recycled back to the sewage collection system. In this way, a small amount of water can be recovered, but the development of gray water recovery methods is a priority option due to low cost and simplicity of implementation.

③ Due to the diversity of the gray water production site and the difference in the quality of gray water, there are other scenarios. But the choice of a particular method requires studying. Because gray water has microbial and chemical contamination. And should be purified to the point of view of the point of use.

The results showed that the IFAS systems have generally suitable productivity for GW treatment, especially to eliminate organic combinations (BOD<sub>5</sub>, COD, TN and TP) and suspended solids, although applying these systems individually do not have enough efficiency for elimination of microorganisms. Consequently, to reach standards for GW reuse, IFAS biological system can applied in mixture with a disinfection or membrane filtration as an applicable alternative technique for GW treatment and reuse.

Suggestions: In order to achieve the real result for the recovery of gray water, the following are suggested:

- (1) Drafting Standard or Guidelines for the Recovery of Gray Water
- (2) Creation of protective packages for the recovery of gray water
- (3) Measuring the true pollution of gray water
- (4) Evaluating the efficacy of different purification methods at or out of the site and its economic evaluation

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