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An Investigation on the Systems of Collecting and Extracting Greywater from Surface Water and Wastewater

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Abstract: Lack of water resources, on the one hand and degradation of the quality of available resources; on the other hand, raise serious concerns about water supply. Limited water resources in some areas necessitate planning for use of unconventional resources, such as: Unconventional and recyclable water resources, which should be used optimally. Therefore, there is an increasing need for use of low-quality water in areas where freshwater is scarce, in which case, unconventional water resources (such as saline water, brackish water and household wastewater) can be considered as valuable resources. The aim of this study was to investigate the possibility of water extraction from household wastewater (greywater) and surface water running in villages in Abadan and to simultaneously evaluate some water collection systems to find the best one in order to use these water resources as unconventional and recyclable water resources for various uses such as: Agriculture and irrigation of date palms. In the present study, we investigated three systems for the collection of surface water and household wastewater (greywater) in villages of Abadan The studied systems included: A conventional system, a small-diameter gravity sewer system and a simplified conventional system. We evaluated the said systems using all three methods in five villages of Abadan County as case studies. While estimating the economic cost of implementing each of these systems and taking into account the existing economic, social and cultural constraints, we recommended the most suitable system for the extraction and collection of wastewater and surface water in the region considering the lack of a system for the collecting and disposal of surface water and wastewater. The results indicated that the small-diameter gravity sewer system was more preferable than the other two methods. The studied villages included Albuhameed Manyoohi, Abudgol of Arvandkenar, Hadd of Arvandkenar, Sadat of Bahmanshir and Tarreh Bakhakh.

Keywords: Extraction, Greywater Collection, Conventional System, Simplified Conventional System, Small-Diameter Sewer System, Abadan

Introduction

Iran is one of the countries located in arid and semi-arid areas and it is faced with the heterogeneous and inappropriate spatial and temporal distribution of precipitation in addition to its low average annual precipitation. These issues, in general, have increased the potential for water shortage and the likelihood of drought in Iran and have even caused a lot of problems in terms of water supply under normal circumstances in some parts of the country, especially in southern and southeast areas. According to available statistics, the excessive extraction of groundwater resources has led to a further decline in groundwater levels and the advance of saline water into some plains mostly located in the central and eastern parts of Iran (Turner *et al*., 2016).

The necessity of planning and managing water supply needs, on the one hand and the limited resources of fresh water available, on the other hand, attract the attention of all managers and experts to the use of available unconventional resources such as saline and brackish water. Accordingly, cities and areas which face shortages of surface and underground freshwater resources and which are mainly located near sea and/or on saline and/or brackish water aquifers, should make maximum use of these resources to obtain their needed water. Therefore, it is considered essential for these areas to make use of modern technologies and solutions to obtain fresh water.

The population growth and the need for development, controlling the quality of water resources and preventing environmental contamination, on the one hand and fighting against contagious diseases and promoting the public health, on the other hand, make the need for collecting and purifying wastewater and surface water more evident (Swamee, 2001).

In each society, a large amount of water is used for various applications such as: Household, public, commercial and industrial uses, which results in the production of wastewater (greywater and blackwater), which is composed of 99.9% water and 0.1% impurities and contaminants. Due to containing physical, chemical and microbial contaminants, if not collected and treated properly, such wastewater will cause serious danger to humans and other components of the environment's natural ecosystem (Arden and Ma, 2018).

An research on the Systems of gathering and Extracting Greywater from Surface Water and sewage Abadan, IRAN was quantified applying faecal index bacteria and chemical biomarkers (Mara *et al*., 2001). A quick, very delicate and elective detector is instantly needed to find pollution incidents in recycled water systems - for instance, cross-connection incidents in dual reticulation pipes that recycle developed acted sewage effluent - as available technologies, containing total organic carbon and conductivity monitoring, cannot always prepare the sensitivity needed (Eregno *et al*., 2018). Fluorescence spectroscopy has been offered as a potential monitoring tool given its high sensibility and selectivity (Chen *et al*., 2003). Due to a absence of sufficient empirical methods, the kinetics of the first 20 s of ozone analysis in innate water and sewage is still poorly understood. These consequences show the applicability of bench scale decided second-order rate stables for sewage ozonation (Maimon *et al*., 2017). significant grades of pharmaceutical oxidation and microbial deactivation are foretoken, denoting that a considerable oxidation possible is accessible during sewage ozonation, even when ozone is quite decomposed in the first 20 s. Stimulation-discharge matrix fluorescence spectroscopy has been widely applied to determine soluble organic matter in water and soil.

Greywater

All wastewater produced at home, except for toilet wastewater, is called "greywater". In other words, greywater is the wastewater from the kitchen, bath and washing machines. Greywater from the bath, dishwashing and laundry makes up approximately 50 to 80% of urban wastewater.

Greywater is reused for the irrigation of gardens. Reuse of greywater reduces consumption of surface and underground water. In arid areas with limited resources of water, it is important to make efficient use of water and preserve it in any ways possible.

Greywater is wastewater which contains a large amount of drinking water and which is used for irrigation when the plant is grown enough to be able to consume water containing particulates (Jeong *et al*., 2018). Unlike short-term methods, reuse of greywater resolves an important part of societies' problems and will remain an indispensable and unchangeable method for the far future (Mara *et al*., 2001).

Advantages of Using Graywater are as Follows:

1) Reduced consumption of healthy water
2) Lower pressure to water treatment systems
3) Being able to build a water treatment unit on a small piece of land
4) Reduced consumption of energy and chemicals
5) Helping the growth of plants
6) A constant and reliable source
7) Positive economic features
8) Easy installation

Use of traditional methods for the disposal of wastewater and surface water such as: Absorption wells, is one of the causes of the contamination of groundwater resources and degradation of water quality. One of the effective ways to reduce the contamination of water resources and control contagious diseases in a society is to build a sewage collection and treatment system, which allocates to itself a large part of investments in each society. Therefore, considering the high cost of building a wastewater-collecting network and a treatment plant, it is of great importance to choose the most suitable system, which is the most efficient while imposing the lowest cost.

Various methods are currently used to collect surface water and wastewater in different parts of the world. Choosing a system to collect wastewater and surface water depends on several factors such as: Population density, the slope of the region, the terrain texture and so on.

In general, the most important systems for collecting sewage, wastewater and surface water are as follows (Swamee, 2001):

a) The conventional system
b) The Vacuum Sewer system (VS)
c) The pressurized system
d) The small-diameter system
e) The simplified conventional system

Unlike in vacuum and pressurized systems, in small-diameter and simplified conventional systems, sewage is collected due to the gravity force and is transferred to the treatment plant. The gravity systems incur lower operating and maintenance costs, because they do not need electrical and mechanical equipment required for the pressurized systems. Hence, in most areas having a suitable topography, gravity methods are used to collect sewage and wastewater (Little, 2004).

Multiple studies have so far been conducted on sewage collection systems and on how to design and select the best system under different conditions.

In 1980, CAERN Company conducted an investigation on how to implement the simplified conventional system in Brazil (Ottoson and AxelStenström, 2003).

In 1999, Swamme offered an algorithm to optimally design sewage collection lines, so that the best way was provided to determine the effective parameters in design, such as: Minimum and maximum excavation depths and minimum speed, in order to reduce costs (Henderson *et al*., 2009).

In a study on the comparison of sewage collection systems in 2004, little compared gravity and vacuum sewage collection systems in Botswana (Buffle *et al*., 2006).

Considering the differences existing between the factors affecting the selection of a suitable sewage collection system in low-density areas and villages and those in densely populated areas and cities, sewage collection systems; especially in villages, should be selected with consideration of economic and sociocultural issues.

In this study, taking account of the implementation cost and sociocultural problems associated with the construction of gravity systems in low-density areas, we offered the best option for collecting household wastewater and surface water in villages of Abadan. We used the small-diameter and simplified conventional systems as sewage and surface water collection systems in five villages located in Abadan County as case studies.

Methods and Materials

Gravity Sewage and Surface Water Collection Systems

The Conventional Collection System

The conventional collection system is usually the best option for the collection of sewage, wastewater and surface water in economic terms and in terms of operational problems in densely populated areas which have a suitable slope for gravity collection and in which the costs of trench digging do not increase tangibly due to high groundwater levels and/or the stone bed. The implementation of conventional gravity networks is usually very costly in low-density, low-slope areas with suitable soil and in areas where the groundwater level is high.

In the conventional gravity method, the flow is connected to the sub-lines through the branch lines of the houses, due to gravity. In this system, sewers must have a minimum slope defined to provide a self-washing speed. In some sewers, which do not have the flow rate required to provide a self-washing speed, it is possible to use washing basins or adopt other measures to provide a washing speed. Main and semi-main sewage canals should also be designed by taking account of the minimum slope required to provide the self-washing speed and/or in a way that deposits are not left over. The minimum diameter for the pipes used in this method is 200 mm, which is considered for the intersections of sewage canals and at maximum distances of 50 to 70 m in straight paths (manholes).

The Small-Diameter Collection System

In this system, the flow is first transferred to septic tanks and after about 24 h of remaining there, the wastewater is transferred from the tanks to the main canals of the collection network.

The collecting canals in this system, are made of flexible pipes, whose minimum diameter is 75 to 100 mm. In this system, a small number of manholes are used in the network, which can be replaced by washing basins, in a way that washing basins are considered at distances of up to 150 m in direct paths in addition to those at the intersections of sewage canals. In the small-diameter collection system, suspended solids are deposited in septic tanks and the outlet flow is transferred by the collection network from the tanks to the water extraction site. Due to the removal of suspended solids, the risk of clogging in the sewage canals will be limited and there will be no need to provide the self-washing speed in the network.

The Simplified Conventional Collection System

This type of network is designed based on the minimum tensile stress which is needed to be provided at the time of peak flow. Tensile stress is a tangent force applied by the sewage flow to the bed floor.

In this system, manholes are located at distances of up to 100 m in straight paths, at points where the flow direction changes and at points where the pipe diameter changes. In this system, there is a need to build grease traps inside kitchens, which will occupy space, which will probably release odors in the space of kitchens in houses and which will cause problems at the time of emptying them. In this method, the minimum slope required for each sewage canal to provide the minimum required tensile stress is calculated through the following relation.

Case Studies

In this study, we used five villages located in Abadan County as case studies to economically compare the implementation and operating costs in different systems of wastewater and surface water collection and finally water extraction. The case studies included the following villages: Albuhameed Manyoohi, Abudgol of Arvandkenar, Hadd of Arvandkenar, Sadat of Bahmanshir and Tarreh Bakhakh.

Abadan County is in the province of Khuzestan located in southwestern Iran. After Ahvaz, this city is the most important city in Khuzestan Province. This city also has an airport and a harbor. And due to its oil refinery, being a strategic city and having a border with Iraq, it has been one of the most important cities in the Middle East and Iran since World War II. One of the world's largest oil refineries (Abadan Oil Refinery) is located in this city. From most parts of Khuzestan, oil is transfered to this city through pipelines and is exported to the whole world after it is refined. The nearest city to Abadan is Khorramshahr, which is located about 15 km from this city. The geographical location of this city is at a longitude of 48° and 16' north and a latitude of 30° and 20' east, its altitude is 3 m above the sea level and has an area of 2,796 square kilometers. Abadan borders Shadegan to the north, Persian Gulf to the east and south, Iraq to the southwest and west, where the natural boundary between them is Arvand River and Khorramshahr to the northwest. This city comprises two parts: Central and Arvandkenar and the studied villages are selected from both parts.

Table 1 show the geographical location and demographic characteristics of the case studies used in this research.

Table 1: The geographical location and demographic characteristics of the case studies

The name of the village	Population in 2011
Albuhameed Manyoohi	1,846
Abudgol of Arvandkenar	2,007
Hadd of Arvandkenar	2,431
Sadat of Bahmanshir	1,809
Tarreh Bakhakh	2,715

Results and Discussion

Hydraulic Comparison

Investigating and evaluating the results showed that in all case studies, the average depth of excavation was less in the small-diameter system than in the other methods, due to not needing to provide the self-washing speed in the sewage canals and consequently reducing the minimum slope required in the small-diameter network. And due to the condition that requires the minimum tensile stress to be provided in the simplified conventional system, the average depth of excavation is greater in this system than in the other methods.

Investigating the flow velocity at the peak of wastewater production indicates that in more than 50% of sewage canals, it is not possible to provide the self-washing speed due to their low slope and low sewage flow rate. Therefore, it is necessary to adopt appropriate measures to prevent network clogging in the conventional system.

Economic Comparison

In what follows, we have economically compared implementation and operating costs in the intended systems. In all case studies, the small diameter system is considered as the least costly system. The operating cost in the conventional system, includes artificial washing of sewage canals due to the fact that the self-washing speed is not provided in most canals. If the slope of canals is sufficient to provide the washing speed in the network, the annual operating cost in the conventional system, will not be significant. The operating cost in the small-diameter system, includes emptying the sludge accumulated in septic tanks, at specified time intervals. In this study, we have considered time intervals of two years for emptying the tanks and one septic tank for each house. The operating cost in the simplified conventional system, includes washing of canals to provide compressive waves in the network; because there are no flush tanks in the lavatories of the village houses. Since the minimum tensile stress to prevent sedimentation is provided in this system, the time interval for washing the canals is longer in this method than in the conventional system.

Sociocultural Comparison

One of the assumptions in the simplified conventional system, is use of flush tanks in lavatories, so that the resulting compressive waves will wash the sewage canals and there will be no need for artificial washing. Failure to install flush tanks in lavatories as well as cultural problems in emptying grease trap units are some of the problems in the simplified conventional system in the country’s villages.

Septic tanks are one of the most important components of the small-diameter system for the removal of suspended solids from wastewater. Use of septic tanks requires sufficient space inside houses. And due to the large size of yards in rural houses in the country, it is possible to build such tanks in rural houses. If there is no enough space to build septic tanks in some houses, shared septic tanks can be used for several houses.

Due to the lack of appropriate culture making in rural areas and because of emptying any kind of unwanted materials in the sewage collection network, the risk of clogging in sewage canals is very high in conventional systems and it will be costly to obviate the clogging in the pipes in a long-term period and the resulting problems will make people dissatisfied with these systems. Whereas, in a small diameter network, those unwanted materials remain in septic tanks and do not enter the network.

By choosing the small-diameter collection system, which is superior to the other two systems, graywater can be extracted from this system and be used for agricultural purposes.

The repeat of grey water for non-drinkable water usages is a possible solution for water-deprived areas global. Enough therapy of grey water prior to repeat is significant to decrease the risks of bacteria conduction and to better the effect of further asepsis (Winward *et al*., 2008). Chlorine is a widely employed antiseptic and as such is a precedent contender for asepsis of grey water wanted for reapply. The result of disinfection was most nearly connected with particle size. Greater particles fendered total coliforms from deactivation and asepsis trace reduced with enhancing particle size. The organic condensation of grey water reliced chlorine request but did not penetrate the asepsis persistence of total coliforms when a free chlorine residual was sustained. It evaluated the proficiency of maerl (calcified seaweed) as a layer for artificial wetland waste treatment systems (Gray *et al*., 2000). This test dispalyed that maerl has great possible as a produced wetland substrate, due to its high phosphorus-adsorbing capacity. Bottom Ash and De-Oiled Soya have been applied as adsorbents for the elimination of a perilous azo dye-Metanil Yellow from its aqueous dilutions. Increased water demands in dry countries, have led to increased assumption of different water apply uses. Irrigation of greywater (all water discharged from the bathrooms, laundry and kitchen apart from toilet waste) is looked as a possible means of mitigate water requests; but, there is finited science of how greywater irrigation effects territorial and lentic circumferences. cumullation and possible effects of metals in soil, groundwater and surface water, as a consequence of greywater irrigation, were recognized by contrasting measured condensations to national and international indexs.

Conclusion

Results obtained from this study showed that the small-diameter collection system was suitable to be used as a graywater collection and extraction network in the villages of Abadan. The following reasons indicate the superiority of this system in brief:

1) Considering the hydraulic comparison of the three collection network systems; i.e., the conventional, small-diameter and simplified conventional systems, the most important hydraulic advantage of the small-diameter system was reducing the average depth of excavation, due to not needing to provide the self-washing speed and consequently reducing the minimum required slope. The reduced average depth of excavation and not needing to provide manholes in this system, will reduce the economic costs of constructing the network
2) The economic comparison between the systems showed the lower implementation and operating costs in the small-diameter system than in the other options. According to the comparison carried out, the simplified conventional system was uneconomical due to the cultural poverty in the country and the need to adopt some measures such as designing man-holes in the network
3) In rural areas, any kind of unwanted small and large materials are emptied into the collection network. Nevertheless, due to the presence of septic tanks in the small diameter system and removal of suspended solids and those unwanted materials in these tanks, there will be no risk of clogging in the network. Whereas, this risk exists in the other systems, where unwanted materials directly enter the network
4) If the slope of the area provides the required speed for washing the sewage canals, the operating cost of the conventional network will decrease and will become equal to the cost of the small diameter system. But, there will still be a risk of clogging in the pipes, due to the direct entry of unwanted materials into the network
5) Removal of suspended solids in the septic tanks of the system reduces the pollution load of the wastewater which is transferred to the graywater extraction tank. By reducing the pollution load of the sewage flow in this system, the costs of the construction and operation of a water treatment plant will be reduced compared with those in the other systems. Therefore, in addition to reducing the implementation and operating costs of the network, use of this system as a wastewater collection network will reduce the implementation cost of the water treatment plant as well
6) Due to use of graywater, very small amounts of H_2S will be produced in the collecting pipes. As a result, graywater collecting pipes will not corrode

7) Because of low concentrations of organic matter in graywater, the pipes will not clog up
8) There will be no need for complicated and expensive systems to refine graywater
9) Due to environmental considerations, graywater irrigation is carried out in the form of underground and drip irrigation. As a result, with the irrigation efficiency increasing, the system becomes more and more economical and the system's benefits will become more evident to the consumers

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Author's Contributions

All authors equally contributed in this work.

Ethics

In this article, all ethical principles related to scientific-research articles such as validity and authenticity, originality, data collection in a standard manner, integrity and accuracy of research, etc. are observed.

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