



Influence of Grey water on Properties of Mortar and Concrete Mixes

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Introduction and Background:

Water situation

- Jordan is located in an arid to semi arid area (50 mm to 600 mm), **Approximately 92.2% of the rainfall evaporates** and considered as one of the top water scarce countries in the world. **Therefore, water reuse is a high priority.**
- Recently, the problem of water shortage in Jordan has been become worse as a result of **high natural population growth**, influxes of **refugees**, **rural to urban** migration and increased standards of living.



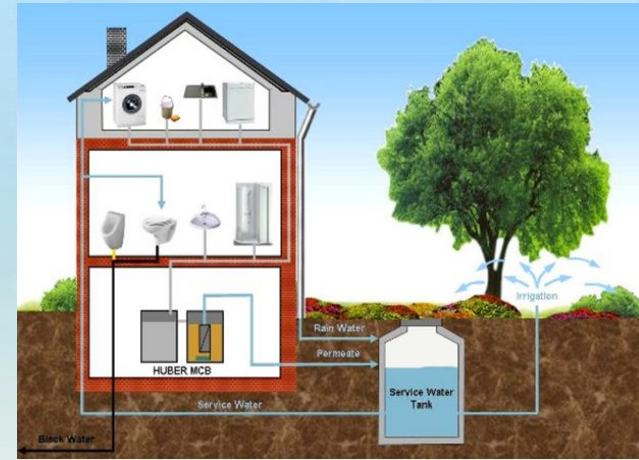
Research problem

- Currently, Construction activities world-wide are expected to expand over the coming years and will consume more fresh water “annually one billion tons of mixing water”
- In Jordan, around 4 Mm³/y of fresh water is needed to prepare ready mix concrete. In addition, another 4 Mm³/y for washing activities and wet curing.
- According to JS it is a must to use fresh water for concrete production
- The treated wastewater is estimated to be around 117 MCM/year in 2020 [1]. Between 50% and 80% of the domestic household wastewater is grey water.
- **Therefore**, grey water treatment and reuse for concrete industry is a high priority and rational action. Such research type is important in order to change people attitude and the legislations.

Grey water

- *Definition*

is all types of wastewater collected from household activities except toilet wastewater



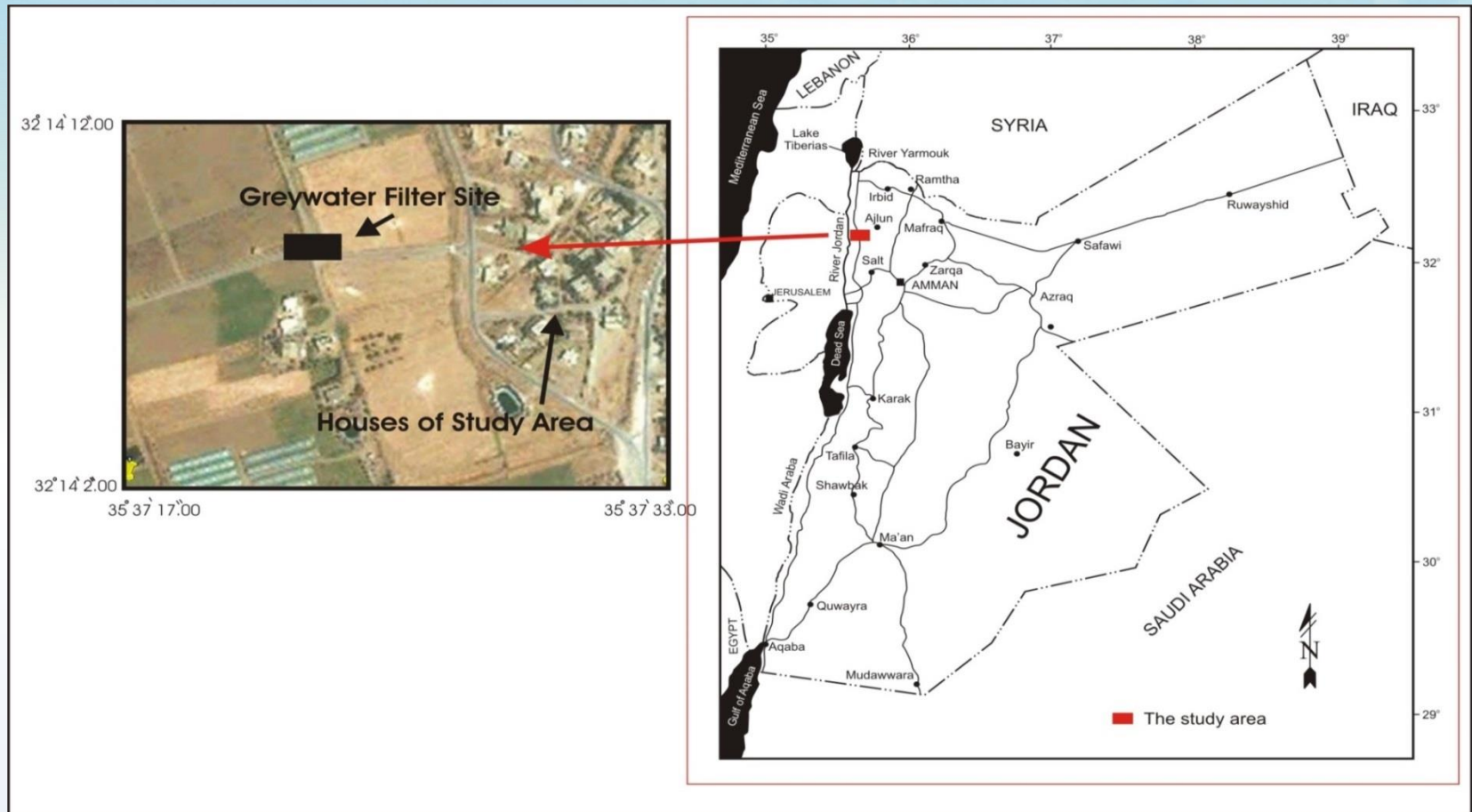
Project objectives

This study aimed to

- Provide a new water resource to sustain the construction activities in Jordan.
- evaluate the potential of reused grey water in concrete and mortar in order to save the fresh water for drinking purposes.



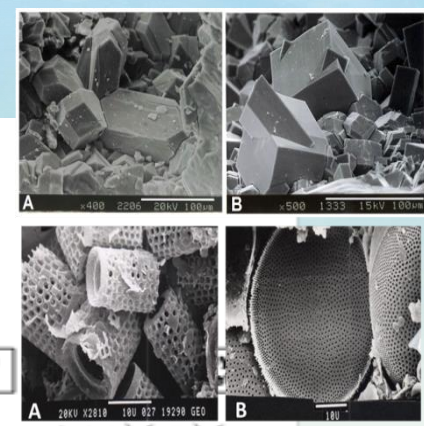
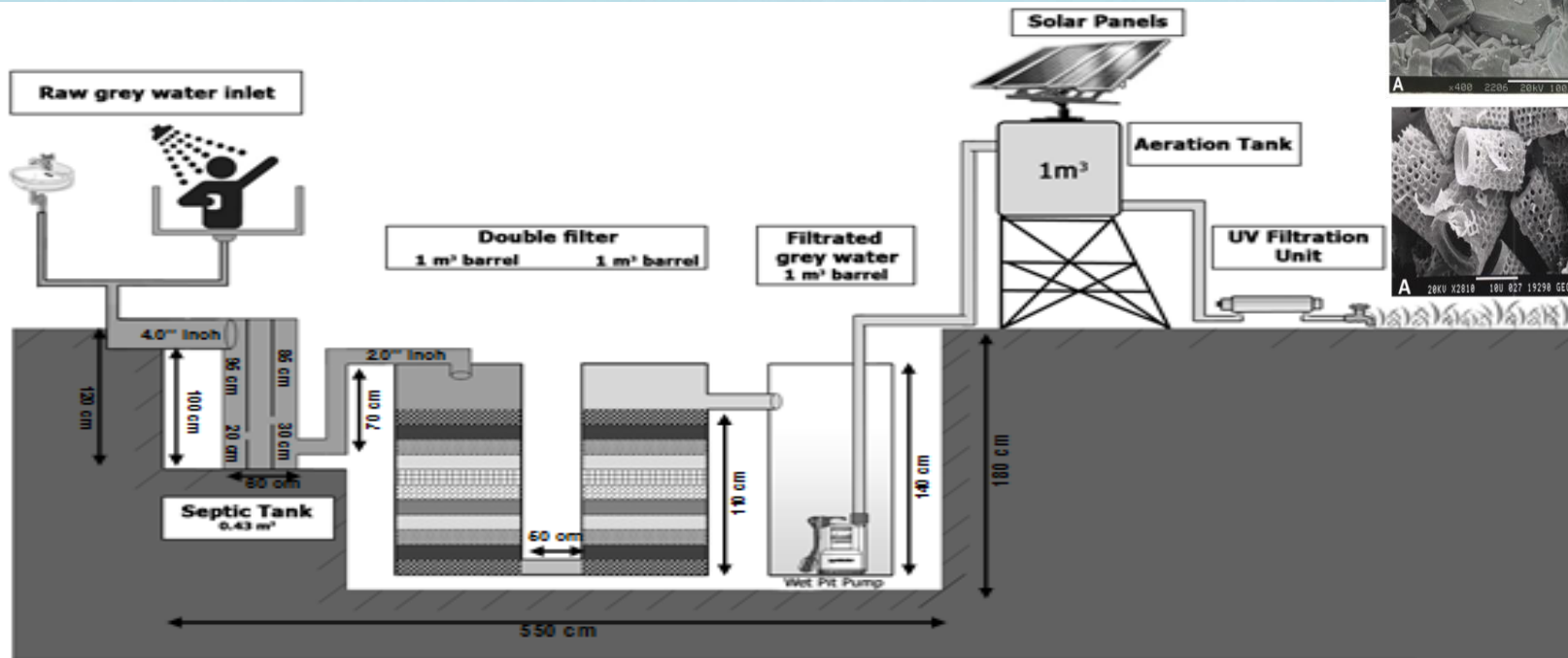
Development of a Grey Water filtration-system Using Jordanian Natural Resources



- Study area \ Deir Alla (Um-Ayyaash area) which is located in the Middle Ghor,
- (rainfall 100 to 150 mm) and (temperature varying from 19 to 36.5°C)



Installation of multi layer filter in Field



- 16mm Dolomite
- Course sand
- Diatomite
- Activated Carbon
- Zeolite
- Fine sand
- 8mm Dolomite

- The pilot plant is running automatically
- The system running cost is zero
- There is no rejected water (Filtration efficiency is 100%)

Materials and Methodology

- Two types of Grey water samples were collected from the pilot plant (RGW and TGW) and analyzed .
 - Coarse and fine aggregates and cement were collected and characterized
 - Concrete and mortar mixes using RGW and TGW as well as Distilled Water (DW) were prepared and casted in cubic and prisms moulds .
 - Fresh properties of mortar and concrete were tested directly.
- Other properties were tested after various curing ages (7, 28, 120, and 200 days).



Mixing, Casting, and Curing, testing for Concrete

Mortar and Concrete Mix Design

Table (1). Proportions of mortar mixes.

| Mix Designation | Fine Aggregate(g) | Cement (g) | Water (g) |
|------------------------|-----------------------------------|-------------------|------------------|
| RGW | 1350 | 550 | 280 |
| TGW | 1350 | 550 | 280 |
| DW | 1350 | 550 | 280 |

Table 2. Concrete Mix designation contents.

| Mix Contents | Median Particle size (mm) | Quantity (kg/m³) |
|-------------------------------|--------------------------------------|--|
| Coarse Aggregate (Hemseyeh) | 9.5 | 514.728 kg |
| Coarse Aggregate (Adaseyeh) | 4.7 | 370.3 Kg |
| Coarse Aggregate (Semsmekeh) | 2.4 | 252.1 Kg |
| Fine Aggregate (Swealeh Sand) | 0.3 | 502.7 Kg |
| Cement | | 418.18 kg |
| Water (RGW, TGW, or DW) | | 233 kg |

Results

Table 2 Grey water quality and the mixing water permissible limits for concrete

| Parameter | Unit | RGW | TGW | *Maximum concentration |
|-----------------|-----------|----------|------|------------------------|
| TSS | mg/L | 436 | 2 | 2000 |
| TDS | mg/L | 980 | 803 | 2000 |
| COD | mg/L | 900 | 6.97 | 500 |
| BOD5 | mg/L | 536 | 2.98 | - |
| Cl | mg/L | 243 | 208 | 500 |
| SO ₄ | mg/L | 222 | 137 | 2000 |
| NH ₃ | mg/L | 24 | 4.5> | No specific limit |
| pH | - | 7.5 | 7.9 | 6-8 |
| E-Coli | MPN/100ml | 1.70E+05 | <1 | **<200 |

*Mixing water permissible limits according to ASTM C94 [30] or EN 1008 [34], [31], and [29]. **The maximum limits for an open system application of wastewater [15].

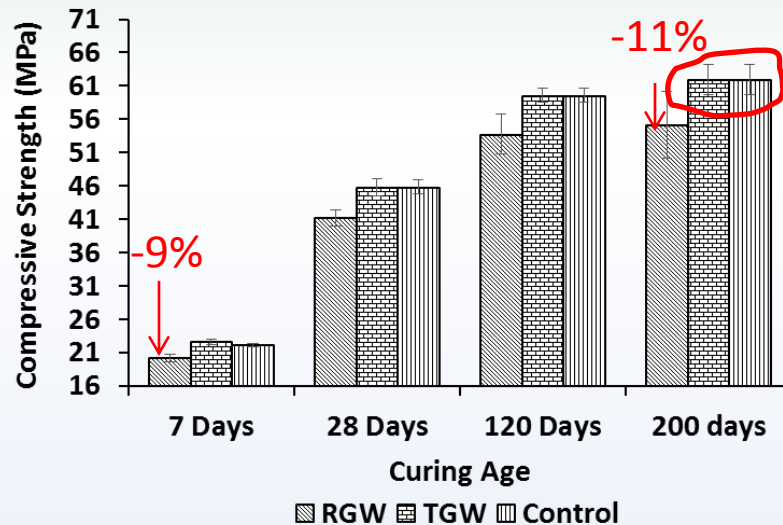
Although the initial raw grey water has high bacteria and organic content, the filtration system was capable to remove all of it

Mortar properties

Table 4 Fresh properties of cement paste

| Water type | Wt. of Cement (gm) | Water (CC) | Water/Cement (%) | Initial Setting time (minutes) | *Needle Penetration (mm) | Soundness (mm) |
|------------|--------------------|------------|------------------|--------------------------------|--------------------------|----------------|
| RGW | 500 | 147 | 29.4 | 200 | 4 | 1 |
| TGW | 500 | 148 | 29.6 | 205 | 4 | 1 |
| Control | 500 | 146 | 29.2 | 180 | 6 | 1 |

*Standard consistency is 6 ± 2 mm [32].



ASTM C109: water is suitable for concrete if mortar made with it have comp. strength at 7 days equal or less than 10 % reduction than of control sample made with distilled water.

Figure 1 Influence of RGW and TGW on mortar compressive strength at various wet curing ages (7, 28, 120, and 200 days).

Mortar Stereomicroscope images

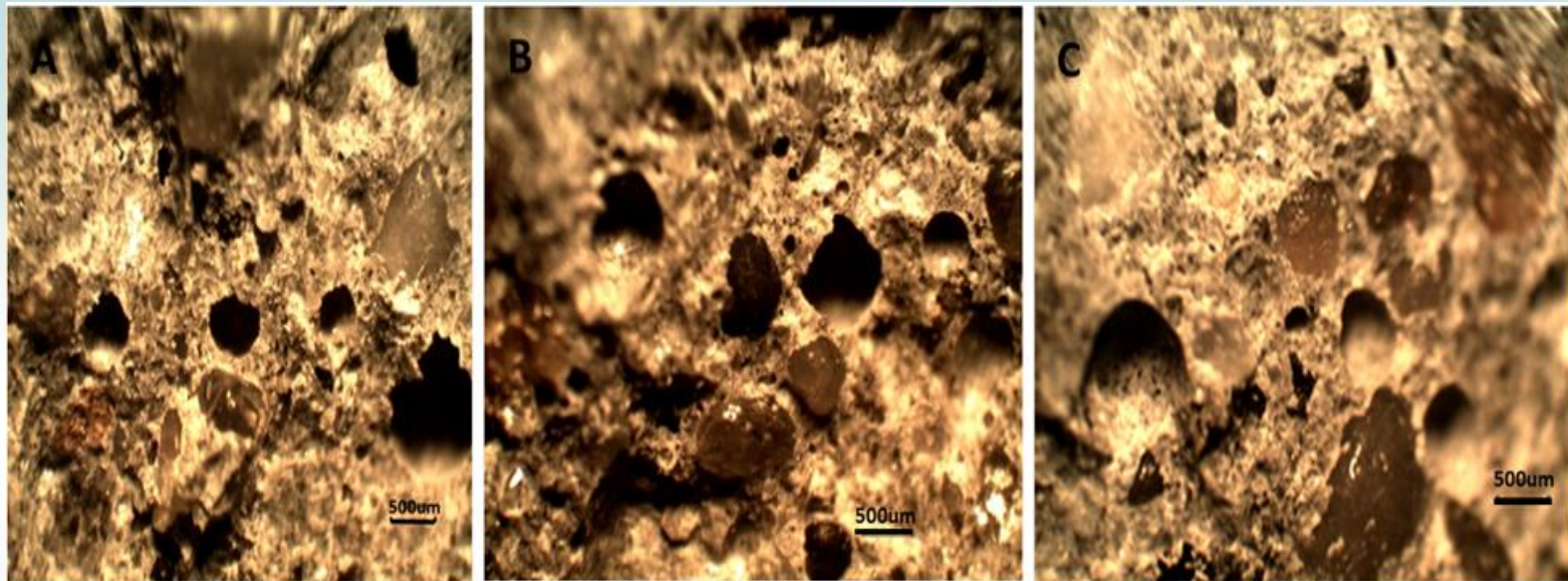


Figure 2 Stereo microscope images of mortar specimens performed with A: TGW, B: RGW, and C: Distilled water. The image was taken at 30X magnification.

Concrete Results

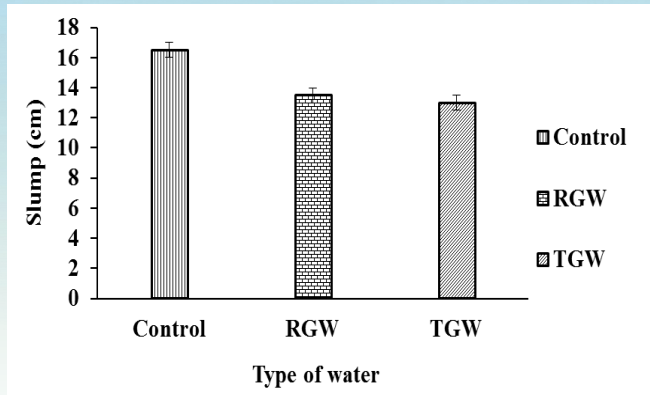


Figure 3 Slump of concrete using RGW, TGW and Distilled water as mixing water.

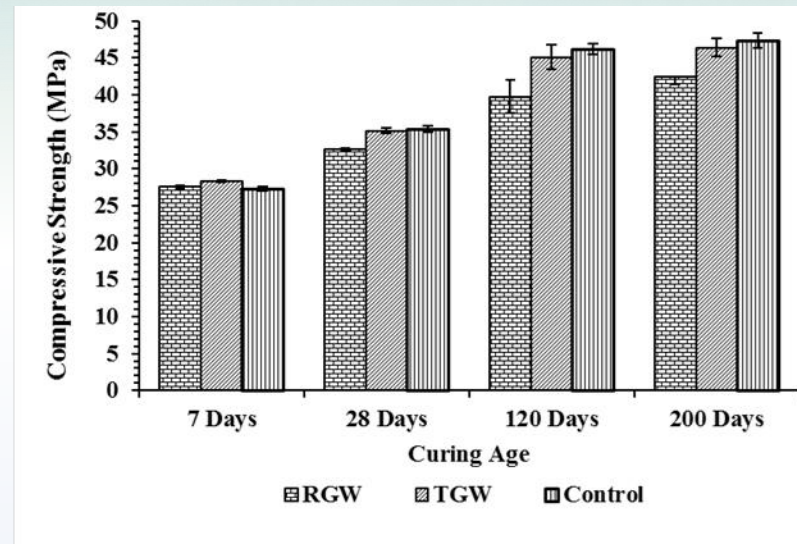


Figure 4 The compressive strength of concrete utilizing RGW, TGW and distilled water at curing age 7, 28, 120, and 200 days.

Dilution effect of RGW on concrete compressive strength

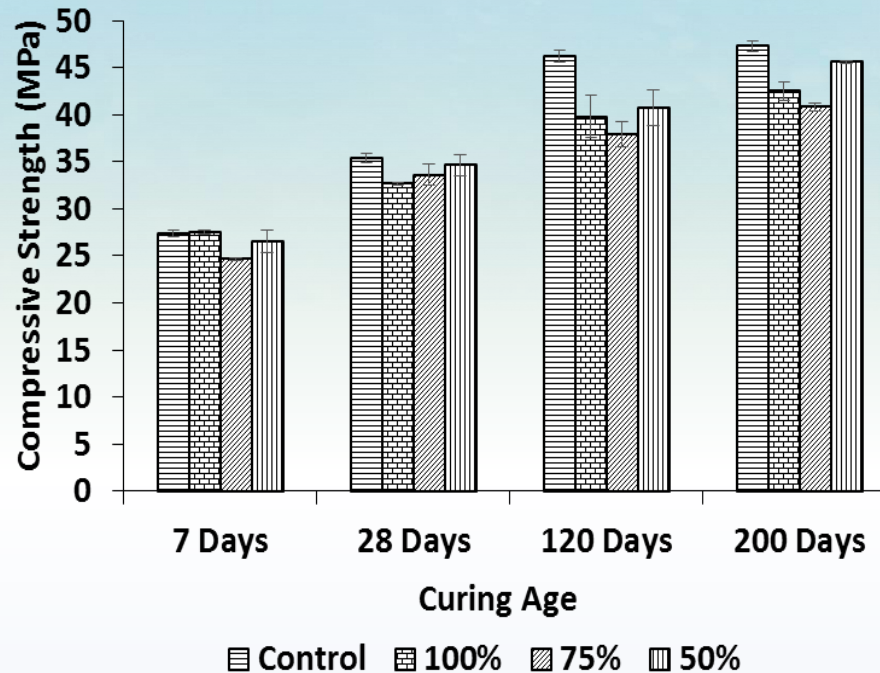


Figure 5 The effect of dilution ratio of RGW ((RGW : Distilled Water); 1:0, 3:1, 1:1) on the development of concrete compressive strength at curing age 7, 28, 120 and 200 days.

Conclusion

- Based on of grey water quality and the Mixing water permissible limits for concrete, the TGW is suitable for concrete production. However, the RGW should be pretreated to reduce the microorganism content before the water can be in direct contact with humans.
- **According to ASTM C94, ASTM C109 requirements and the IS 456, TGW and RGW are suitable for concrete production.**
- In conclusion, TGW and RGW are a **potential alternative** for fresh water in concrete industry.



Four Scientific Papers and one Patent

Water 2012, 4, 580-596; doi:10.3390/w4030580

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Article

1- Grey Water Reuse for Agricultural Purposes in the Jordan Valley: Household Survey Results in Deir Alla

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<http://www.mdpi.com/2073-4441/4/3/580>

2- Performance of grey water pilot plant using a multi-layer filter of natural materials for agricultural purposes in the Jordan valley. Clean-Soil, Air, Water – Wiley-VCH, 43 (3), 351-359. DOI: 10.1002/clen.201300488.

Ghrair, A.M, Almashaqbeh, O., Megdal S. (2015).

<http://onlinelibrary.wiley.com/doi/10.1002/clen.201300488/abstract>



3- A portable device for converting grey water to potable water

Jordan/Ministry of industry and trade/Directorate of industrial property

Patent No. 2924

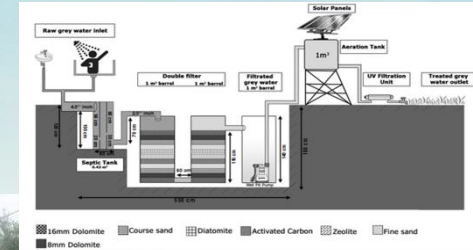
Year 2015

4-Influence of Grey water on Physical and Mechanical Properties of Mortar and Concrete Mixes. Ain shams Engineering Journal (**Submitted**)

5-Domestic Wastewater Reuse in Concrete Using Bench-Scale Testing and Full-Scale Implementation. Water Journal(**Submitted**)



Thank you!



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