****

**REPUBLIC OF YEMEN**

**UNIVERSITY OF ADEN**

**FACULTY OF ENGINEERING**

**Civil Engineering Department**

**Water Resources & Environmental Engineering Section**



**Master Degree Thesis**

**on**

**Utilization of Mosque Ablution Wastewater**

**Submitted by:**

**Civil Eng. Adel Mohammed Raweh**

**SUPERVISED by:**

**Dr. Zaki Mohammed Othman**

**Aden- 2010**

**REPUBLIC OF YEMEN**

**UNIVERSITY OF ADEN**

**FACULTY OF ENGINEERING**

**CIVIL ENGINEERING DEPARTMENT**

**Utilization of Mosque Ablution Wastewater**

**Prepared BY : SUPERVISED BY :**

**Civil Eng**. **Adel Mohammed Raweh Dr. Zaki Mohammed Othman**

1996

**Associate professor civil**

**Eng. department faculty**

**Of Eng. Inv. Of Ade**n

**This thesis has been submitted to the faculty of engineering – university of Aden as part of the requirement for the Master Degree .**

**Abstract**

Yemen is facing severe water poverty. The main water source, groundwater from wells, suffers from large and uncontrolled extraction and increasing pollution from residential and agricultural use. In addition, mosques are big users of potable water because their patrons perform a cleansing ritual (ablution) before prayer. The water used for this ablution is considered “grey water” and enters the sewage system, which further strains the already scarce water supply.

Any water that has been used in residential and community buildings (Mosques), except water from toilets, is called grey water. Dish, shower, sink, laundry and ablution water comprise 50-80% of residential "waste" water. This may be reused for other purposes, especially landscape irrigation in urban areas.

It's a waste to irrigate with great quantities of drinking water when a considerable quantities of ablution water, which usually drained to the common sewers, from the Mosques are available. Unlike a lot of ecological stopgap measures, grey water reuse is a part of the fundamental solution to many ecological problems and will probably remain essentially unchanged in the distant future. The benefits of reuse includes lowering fresh water use, decrease energy and chemical use, reclamation of otherwise wasted nutrients, income increase by adding irrigated land and increasing water availability and green cover.

Case study in Aden Gov. aimed to estimate the quantity and quality of ablution water effluent, to apply appropriate irrigation system and adapted for the region plants.

The results of the study show that there is sufficient quantity of ablution water to irrigate surrounding the mosques landscape, the quality of ablution water mostly within the standard limits, and the survey of the appropriate for the project plants show that there are a verity of ornamental plants in the region satisfying any landscape design.

الملخص

تواجه اليمن فقر حاد في المياه، والمصدر الرئيسي للمياه وهي المياه الجوفية من الآبار يعاني من الضخ الجائر والعشوائي والتلوث المتفاقم بسبب الاستخدام المنزلي والزراعي. بالإضافة إلى ذلك تأتي المساجد كمستخدم كبير للمياه الصالحة للشرب من قبل المصلين لغرض الوضؤ. وتعتبر المياه المستخدمة للوضوء "مياه الرمادية" وتدخل في نظام الصرف . وكل ذلك يضاعف مشكلة التزود بالمياه النادرة أصلاً.   
     كل المياه المستخدمة في المباني السكنية والمساجد، باستثناء المياه المراحيض يسمى المياه الرمادية مثل مياه أحواض غسل الأيدي، الدش، أحواض الاغتسال، ومياه الوضوء وتشكل نسبة 50-80 ٪ من المياه الصرف الصحي، والتي يمكن إعادة استخدامها لأغراض أخرى مثل ري المسطحات الخضراء في المناطق الحضرية.   
     من الهدر الري بكميات كبيره من المياه الصالحة للشرب في الوقت الذي تتوفر فيه كميات لابأس بها من مياه الوضؤ المستخدمة في المساجد والتي عادة ما تصرف إلى المجاري العامة.

وبعكس كثيراً من الإجراءات البيئية المعقدة استخدام المياه الرمادية يعتبر جزء من الحل الأساسي لكثير من المسائل البيئية و سيبقى كذلك على الأرجح بدون تغيير على المدى المنظور.

تشمل فوائد إعادة استخدام المياه الرمادية تقليل من استخدام المياه الشرب وتخفض من استخدام الطاقة والكيميائيات واستصلاح مواد التغذية للنبات التي يفترض إتلافها وزيادة الدخل بإضافة أراضي مروية وزيادة المياه المتاحة في الرقعة الخضراء.

دراسة الحالة في محافظة عدن هدفت إلى تقدير كمية ونوعية مياه الوضوء المصروفة واستخدام نظام الري المناسب وكذلك النباتات الملائمة.

أظهرت نتائج الدراسة أن هناك كميات كافية من مياه الوضوء لري المساحات المزروعة المجاورة والمحيطة بالمساجد وأن نوعية مياه الوضوء في الحدود الممسوحة على الأغلب، وكذلك أظهر المسح الميداني للنباتات المناسبة للمشروع بأن هناك تنوع كافي من نباتات الزينة في المنطقة تلبي أي تصميم للمساحات الخضراء.

**INTRODUCTION**

**1.1. Definition**

Any water that has been used in the home, except water from toilets, is called grey water (toilet water is called black water). Ablution, shower, laundry and kitchen water comprise 50-80% of residential "waste" water, of which ablution water forms 21%, as shown in figure 1.1. This may be reused for other purposes, especially landscape irrigation.

Ablution

;

2L

;

21%

Shower

/

Bath

30L

25%

Laundry

;

20

L

17%

kitchen

;

10L

8%

Toilet

;

35

L

29%

**Figure 1.1. Sources of Greywater**

**1.2. Key Differences Between Greywater and Blackwater**

- Greywater contains far less nitrogen than blackwater; nine-tenths of the nitrogen contained in combined wastewater derives from toilet wastes (i.e., from the blackwater). Nitrogen is one of the most serious and difficult-to-remove pollutants affecting our potential drinking water supply.

- Greywater contains far fewer pathogens than blackwater; medical and public health professionals view feces as the most significant source of human pathogens. Keeping toilet wastes out of the wastewater stream dramatically reduces the danger of spreading such organisms via water.

- Greywater decomposes much faster than blackwater; the implication of the more rapid decomposition of greywater pollutants is the quicker stabilization and therefore enhanced prevention of water pollution.

**1.3. Formulation of the problem**

Like many countries of world, Yemen is facing severe water poverty. The main water source, groundwater from wells, suffers from large and uncontrolled extraction and increasing pollution from residential and agricultural use. In addition, mosques are big users of potable water because their patrons perform a cleansing ritual (ablution) before prayer. The water used for this ablution is considered “grey water” and enters the sewage system, which further strains the already scarce water supply. Therefore, the reuse of cleansing water (ablution water) from mosques for landscape irrigation is considered.

Among all sources of greywater ablution water may be considered the best in terms of probable organic load and chemical content, of course, if all precautions observed.

The degree of pollution of ablution water, like most wastewater, depends upon the use behavior of the community. So, if the water used for only ablution as a pre-prayer ritual the only possible pollutants are the human excreta from mouth, nose and skin, mainly mucus, saliva and sweat to gather with the other possible adhered to the skin dirt.

Other possible pollutant may be the chewed "Qat" or "Tumbol" and "Shamma" (snuff) all are a plant leaves, except that to "Tumbol" a lot of aroma herbs are added to give a good adore and taste in the mouth of the user, and to "Shamma" usually lime and ash are added to tobacco grind, the main ingredient of "Shamma", in order to enhance its effect.

But the potential danger comes from the use of cleaning chemicals for the ablution places, such as; detergents, bleach (Clorox, flush…etc.) and other cleaners. The adverse influence of cleaning chemicals on landscaping vegetation was noticed at least in one of the sites where ablution water used for landscape irrigation.

## 1.4. The benefits of grey water recycling

It's a waste to irrigate with great quantities of drinking water when plants thrive on used water containing small bits of compost. Unlike many ecological stopgap measures, grey water reuse is a part of the fundamental solution to many ecological problems and will probably remain essentially unchanged in the distant future. The benefits of grey water recycling include:

CONCLUSION & RECOMMENDATION:

Ablution water is may be contaminated with micro-organisms (bacteria, viruses, fungi and human rotal, nasal and skin excreta). These may supply the plant natural fertilizers . The potential danger comes from the use of cleaning chemicals for ablution places such as detergent, bleach and surfactant . Ablution water is best of greywater.

The following measures are recommended for implementation from the municipal when town planning:

* Separate the ablution water system from the common sewer system for the mosques , schools , houses new building or existing Hand wash basins are recommended to be mounted with dispose to sewer at the entrance to ablution places for hand wash and mouth wash and spilt of Qat or Tombol or Shamma (snuff) or what else.
* Use gloves when cleaning ablution filters. Wash your hands after contact with ablution water.
* Diversion system is ‘fail-safe’ that is, ablution water will manually be diverted to the sewer system using by valve.
* Apply ablution water to the landscape by sub-surface irrigation. This will reduce human exposure to the water.

Never store untreated ablution water for more than 24 hours

* Do not allow the soil to become saturated.
* Ablution water is best suited to the irrigation of plants, trees, and shrubs.
* Drip irrigation hoses with holes of at least 3mm diameter should be provided.
* Don t used a ablution water with sprinklers.
* Don’t apply ablution water to lawns, or to fruits and vegetables that are eaten raw.
* Ablution water should not contain water used to wash soiled diapers or generated by anyone with an infectious disease. In both cases, ablution water should make another pipe to the sewer system if overflow ablution water.
* Training of maintenance and operation of ablution system should be organized for the personals who take car of the mosque.

|  |  |  |  |
| --- | --- | --- | --- |
| **Content** | | | |
| **LIST OF TABLES** | | | 1 |
| **LIST OF FIGURE** | | | 2 |
| **LIST OF PHOTO** | | | 3 |
| **ABBREVIATIONS** | | | 4 |
| **Abstract** | | | 5 |
| **Thesis** | | | 6 |
| **Chapter 1: Introduction** | | |  |
| **1.1.** | **Definition** | | **7** |
| **1.2.** | **Key Differences Between Greywater and Blackwater** | | **8** |
| **1.3.** | **Formulation of the problem** | | **8** |
| **1.4.** | **The benefits of grey water recycling** | | **9** |
| **1.4.1.** | **Lower fresh water use** | | **10** |
| **1.4.2.** | **Less strain on septic tank or treatment plant** | | **10** |
| **1.4.3.** | **Highly effective purification** | | **10** |
| **1.4.4.** | **Site unsuitable for a septic tank** | | **10** |
| **1.4.5.** | **Less energy and chemical use** | | **10** |
| **1.4.6.** | **Groundwater recharge** | | **11** |
| **1.4.7.** | **Plant growth** | | **11** |
| **1.4.8.** | **Reclamation of otherwise wasted nutrients** | | **11** |
| **1.4.9.** | **Increased awareness of and sensitivity to natural cycles** | | **11** |
| **1.5.** | **The Recent study** | | **11** |
| **Chapter 2: Literature Review** | | |  |
| **2.1.** | **Yemeni Traditional Practice of Ablution Water Reuse** | | **13** |
| **2.2.** | **Greywater pollution** | | **13** |
| **2.2.1.** | **Primary pollution** | | **13** |
| **2.2.2.** | **Secondary pollution** | | **14** |
| **2.3.** | **Reuse Consideration** | | **15** |
| **2.4.** | **Chemical Constituent of Household Cleaners and Detergents** | | **15** |
| **2.4.1.** | **Bleach** | | **15** |
| **2.4.1.1.** | **Mechanism of bleach action** | | **16** |
| **2.4.1.2.** | **Sodium hypochlorite** | | **18** |
| **2.4.1.3.** | **Calcium hypochlorite** | | **18** |
| **2.4.1.4.** | **Sodium bisulfate** | | **18** |
| **2.4.1.5.** | **Sodium carbonate** | | **19** |
| **2.4.1.6.** | **Sodium chloride** | | **20** |
| **2.4.1.7.** | **Sodium lauryl sulfate** | | **20** |
| **2.4.2.** | **Detergent** | | **21** |
| **2.4.2.1.** | **Laundry Detergent** | | **22** |
| **2.4.2.2.** | **Surfactant** | | **23** |
| **2.4.2.3.** | **Powdered or Granular Solid Detergents** | | **26** |
| **2.4.3.** | **Detergents Environmental Impact** | | **26** |
| **2.5.** | **greywater safety guidelines** | | **27** |
| **2.6.** | **Bacterial, Viral and Fungal Contaminants** | | **30** |
| **2.6.1.** | **Pathogenic bacteria** | | **30** |
| **2.6.2.** | **Pathogenic viruses** | | **31** |
| **2.6.3** | **. Fungal Diseases** | | **32** |
| **Chapter 3: Chap 3 Methodology** | | |  |
| **3.1** | **Ablution Water Quantity Surveying** | | **33** |
| **3.2.** | **Testing of Chemical Content and Carbonates** | | **33** |
| **3.2.1.** | **Picking Samples** | | **33** |
| **3.2.2.** | **Hardness Measurement** | | **34** |
| **3.2.3.** | **Testing Equipments** | | **35** |
| **4** | **Digital Titrator** | | **36** |
| **3.2.3.1.** | **Iron, Total** | | **36** |
| **3.2.3.2.** | **Chromium, Hexavalent** | | **37** |
| **3.2.3.3.** | **Fluoride** | | **37** |
| **3.2.3.4.** | **Nitrate** | | **39** |
| **3.3.** | **Survey of Tolerant Plant Species** | | **39** |
| **3.4.** | **Description of Ablution Water Irrigation System in Situ** | | **39** |
| **3.5.** | **Lists of Probable Pathogens and Harmful Chemical Compounds** | | **39** |
| **Chapter 4: Case Study (Data & Analysis)** | | |  |
| **4.1.** | | **Ablution Water Reuse for Landscape Irrigation Project** | **40** |
| **4.1.1.** | | **Component of Greywater Irrigation System** | **40** |
| **4.2.** | | **Chemical Analysis** | **47** |
| **4.3.** | | **Ablution water Reuse System Performance** | **47** |
| **Chapter 5:** | | **Results** |  |
| **5.1.** | | **Results of Quantity Analysis** | **52** |
| **5.1.1.** | | **Estimation of Water Consumption for Ablution** | **52** |
| **5.2.** | | **Results of Chemical Analysis** | **54** |
| **5.3.** | | **Result of Ornamental Plant Survey** | **62** |
| **Conclusion & Recommendation** | | | **68** |
| **References** | | | **70** |