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Integrated Water Management for Lafarge Cement-Jordan

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***Abstract*—**This study aims at implementing integrated water resources management principles to the Lafarge Cement Jordan at Al-Fuhais plant. This was accomplished by conducting water audits at all water consuming units in the plant. Based on the findings of the water audit, an action plan to improve water use efficiency in the plant was proposed. The main elements of which are installing water saving devices, re-use of the treated wastewater, water harvesting, raising the awareness of the employees, and linking the plant to the water demand management unit at the Ministry of Water and Irrigation.

The analysis showed that by implementing the proposed action plan, it is expected that the industrial water demand can be satisfied from non-conventional resources including treated wastewater and harvested water. As a consequence, fresh water can be used to increase the supply to Al-Fuhais city which is expected to reflect positively on the relationship between the factory and the city.

***Keywords*—**Integrated water resources management, non-conventional water resources, water awareness, water demand management, water harvesting, water saving devices.

I. Introduction

JORDAN'S area is about 89,287 km^2, 90% of which receives less than 200 mm/year of rainfall. The total renewable water is estimated at 870 Million Cubic Meters per year [1]. The total demand in 2008 was about 1,500 MCM which shows that Jordan suffers from severe water deficit that has been satisfied through unsustainable over-abstraction of groundwater [2].

According to the records provided by the Integrated Regional Information Networks (IRIN), Jordan is one of the most water-insecure countries in the world. The average per capita water share in Jordan is five times less than that of the European counterparts. Jordan has been dealing with a dry-spell over the past few years, and it is likely to have an even lower per capita share in the future. Therefore Jordan presently tries to harvest every drop of rainfall [3].

According to the Ministry of Water and Irrigation (MWI), Jordan's severe water shortage, is a motive for all water consumers to improve their water use habits by implementing Integrated Water Management Practices (IWMP) to help bridge the gap between supply and demand, [4] The Industrial Sector in Jordan.

A study conducted by the Jordan Chamber of Industry (JCI) in 2007, confirms that the industrial sector is the main contributor to Jordan's economy which contributed about 22.5% to the Gross Domestic Product (GDP) in 2005. Furthermore the industrial sector contributes about 90% to the national exports and employs about 15% of the country's labor force [5].

Based on the administrative board of Jordan Chamber of Industry report issued in 2008, the data provided by the local chambers (chambers of industry in Amman, Zarqa and Irbid) showed that approximately 14,901 enterprises are operating in the industrial sector. These enterprises employ about 206,352 people. The total registered capital of these enterprises was 2,900 million Jordan Dinar in 2008 [6]. These figures highlight the importance of the industrial sector to the socio-economic development of the country.

During the year 2007, Jordan's industrial sector consumed about 49.2 MCM of water, which made about 5.2% of the total water demand in Jordan in that year [7]. The National Water Master Plan of Jordan shows that the industrial water demand will increase to about 120 MCM by the year 2020. Fig. 1 shows the projected growth in the different demand categories in Jordan until the year 2020 [8].

The Large-scale industries in Jordan are phosphate and potash mining, cement production, fertilizers and petroleum refining. These large industries contribute the lion's share of the industrial water consumption in Jordan, about 86%, which made about 32 MCM for the year 2001 [8].

One of the most important issues about the water use in the industrial sector is that it consumes fresh water which can be used for domestic purposes. At the same time, the industrial sector generates huge quantities of wastewater which can cause significant harm to the surrounding environment if not managed properly.

There is no doubt that the industrial sector is vital to the socio-economic well-being of Jordan, however, the water quantities which are consumed in the industrial sector have to be managed in a more wise and efficient way as the industrial water demand is increasing in the face of a dire water shortage. Furthermore, the negative environmental impacts of industrial wastewater are another crucial issue that needs to be dealt with efficiently. Needless to say that the more efficient use of water in the industrial sector has a double benefit, it saves water and reduces industrial wastewater volume.

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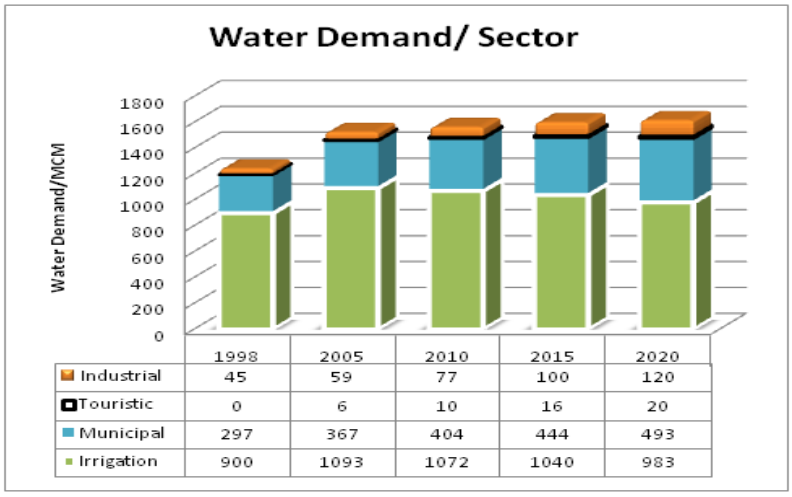

Fig. 2 Water demand by sector in Jordan (MWI, 2004)

II. Objective

This study aims at implementing the principles of Integrated Water Resources Management at Lafarge cement Jordan, Al-Fuhais plant in order to promote water conservation and environment protection.

III. Lafarge Cement Jordan

Lafarge cement Jordan is part of Lafarge group which holds a top-ranking position in the world production of cement, concrete, aggregates and gypsum with nearly 84,000 employees in 79 countries as mentioned in the sustainability report [9]. Lafarge cement Jordan, Al-Fuhais plant, is one of the largest industrial water consumers in Jordan. The plant has 18 occupied buildings, including administrative and industrial units, in addition to the housing which includes 178 units, including two schools, a clinic, and a mosque. Lafarge Cement at Al Fuhais consumed about 1140 m^3/day in 2008. Due to the large water consumption at Lafarge cement Jordan, implementing the principles of integrated water resources management at the factory is essential for water conservation and environment protection.

IV. Methodology

This section describes the methodology followed to achieve the objective of this study. The methodology consists of data collection, field visits, internal audit, and interviewing stakeholders. The methodological steps in chronological order- are as follows:

1. Extensive field visits to Lafarge Cement Jordan, Al-Fuhais plant, and interviewing the directors of the environment department, the production department, the safety department and the administration department to Identify the amount of water consumed, the methods of documentation, and the possibility of decreasing water consumption.
2. Conducting internal audit at Al-Fuhais plant for each water consuming unit. Internal audit was performed as follows:
   - Reviewing the plant's available water resources,
   - Determining the quantity of pumped water to each water consuming unit in the plant, according to the records,
   - Estimating consumed water for each water consuming unit in the plant, and
   - Estimating water demand for each water consuming unit in the plant, not including water losses by practical observations at each unit.
3. Developing an action plan for water conservation at Lafarge cement Jordan for all water consuming units at Al-Fuhais factory.
4. Visiting Al-Fuhais municipality to identify the water situation at Al- Fuhais city and to obtain the records of the water demand for the municipality, in order to establish a link between the factory and the city to help the industry gain public acceptance,
5. Visiting the Ministry of Water and Irrigation in order to establish collaboration network with the Demand Management Unit for implementing water awareness programs in the plant and in the housing,
6. Presenting the findings of the study and the action plan which is supposed to improve water management in the factory to the managers of the plant,

VI. Water Resources At Al-Fuhais Plant

There are four main water resources at Al Fuhais plant which are Mahis well, Al Alali spring, reuse of treated wastewater and a rainwater collection pool. Table I summarizes these resources and their uses.

TABLE I
SUMMARY OF WATER RESOURCES AT AL-FUHAIS PLANT

Resource	Quantity m^3/month	Use
Mahis Well	21690	Domestic, Industrial, and
Al Alali spring	4980	Industrial
Treated wastewater	3600	Industrial
Collection pool	4200	Industrial
Total	34470	Industrial

VI. WATER DEMANDS AT AL-FUHAIS PLANT

Demands at Al-Fuhais plant are domestic, industrial and agricultural. Domestic demands include water demand at the housing as well as water demand at the administrative offices, the school, the guest house and the mosque. Table II summarizes demands at the factory as well as the recorded consumption for the year 2008. Domestic demand was estimated on the basis of the number of residents and employees and the per capita use, industrial demand was estimated based on the internal audit for all water consuming units at the plant assuming full capacity and 30 working days per month. Water consuming units in the plant are the quarry, the raw mills, the conditioning tower and filters, the kilns, the cooler, the cement mills and roads spraying to reduce dust. It is important to note that the conditioning tower and the filters contribute about 69% of the industrial water demand in the plant. Agricultural demand was estimated by the agricultural department assuming that the flood irrigation system in the plant will be replaced by a drip irrigation network. Consumption was taken from the production department.

The difference between pumped water and consumed water in Table II is due to physical leaks from the distribution system which is estimated at 5366 m^3/month while the difference between demand and consumption is due to losses at the demand site, i.e. due to mismanagement and leaks at the demand site which is estimated at 9940 m^3/month. The total losses are estimated at15,256 m^3/month which makes about 78% of the total demand.

TABLE II
DEMANDS AND CONSUMPTION FOR THE YEAR 2008 FOR THE DIFFERENT DEMAND CATEGORIES

Category	Demand, m^3/month	Consumption, m^3/month	Pumped water, m^3/month
Domestic	5,550	12,000	
Industrial	13,675	16,940	
Agricultural	225	450	
Total	19,450	29340	34,706

Table I shows that the total available water at the plant from all the resources is 34,470 m^3/month which is much higher than the demand. Investigations of Tables I and II show that industrial and agricultural demand can be met from Al Alali spring, treated wastewater and harvested water in addition to little amount from Mahis spring. Furthermore, the production of Mahis spring is much more than the domestic demand at the factory which means that the surplus water which is considerable can be used to enhance the domestic supply to Mahis city.

VII. ACTION PLAN

For the purpose of improving water management in the plant the following action plan as summarized in Table III is proposed.

VIII. EXPECTED RESULTS

The analysis showed that by implementing the action plan at Al-Fuhais plant the following results can be achieved:

1. Al-Fuhais plant will have surplus water especially from water harvesting. Surplus water from Mahis well can be used to enhance the domestic supply for the city,
2. The factory will move forward towards gaining the local community acceptance by allocating the saved water from Mahis well to the local community, reducing dust emissions to the environment and preventing flood of the harvested water to the surrounding community, in addition to the possibility of increasing green areas as a result of water availability,
3. Save considerable amount of money used to pay for the water from Mahis well, since the plant pays 25 piaster/m^3. According to this study the plant will save about 500 m^3/day from Mahis well which translates into about 45,625 JD/year.

X. CONCLUSIONS

A water audit was conducted at Lafarge Cement Jordan at Al-Fuhais plant for the purpose of water conservation and environment protection. Based on the findings of the water audit an action plan that aims at improving water resources management and protecting the environment was proposed. The main components of the action plan are creating a water management unit at the factory, maintaining the water distribution system to minimize physical losses, installing metering devices at the different water consuming units in the factory to help conduct water audit in the future, using B.F. in the cooling tower in the first production line which consumes less water, sealing of the cooling system in the second production line used to cool the kilns to reduce water leakage, improve the air cooling system to reduce water use for cooling, maintain water taps in the factory and in the housing to reduce dripping, use drip irrigation for irrigating trees, maintain the water distribution system of the housing to reduce leakage, use Mahis well for domestic purposes only, implement water harvesting at the factory more efficiently, and implementation of a water awareness program.

It is expected that by implementing the proposed action plan the industrial water demand can be satisfied from the non conventional sources, surplus water from Mahis well can be used to satisfy domestic demands in the city. The relationship between the factory and the surrounding community is expected to improve significantly as a result of improving the environment in the surroundings of the factory. In addition it is projected that significant amount of money which is paid for buying the water from Mahis well will be saved.

TABLE III
SUMMARY OF THE ACTION PLAN

Category	Current situation	Action
Water Management	Responsibility shared among different departments	Establish an independent water management unit
Water Distribution Network	Old and leaks considerable amounts of water	Maintain the water distribution network
Metering System	Meters are old. Their readings are not reliable	1. Maintain meters, 2. Install meters at tanks and at other water consuming units to improve water auditing at the factory
Conditioning towers and filters	Two types of filters exist which are Electrostatic Precipitator (E.P.) Filter and Bag Filter (B.F.). The B.F. consumes less water and emits less dust to the environment.	Replace E.P. Filter with B.F. at the first conditioning tower to save water and protect the environment
Kilns	There are too cooling systems for the Kilns the first one is sealed and consumes about 110 m^3/month the second one is not sealed and uses 900 m^3/month	The second cooling system should be sealed which should save about 225 m^3/month.
Air cooling system	Air cooling system is inefficient so water is used for cooling,	By improving the efficiency of the air cooling system about 800 m^3/month of water will be saved.
Water taps	About 50% of water taps are broken	Should be maintained to reduce leakage.
Agriculture	Currently flood irrigation is used by fresh water,	Use drip irrigation and treated wastewater instead of fresh water. This will save about 225 m^3/month
Housing	1. Water distribution system is old, and includes damaged pipes. 2. Meters are not installed at all houses and not protected, 3. Meters are not read regularly, 4. Water for houses if free of charge,	1. Maintain the water distribution system for the housing to reduce leakage, 2. Water meters should be installed and protected against vandalism, 3. Meters should be read regularly, and 4. Certain water tariff should be considered.
Mahis Well	Used for domestic, industrial, and agricultural demands	Use for domestic only
Water harvesting	There exists a water harvesting system. However the volume of the collection pool is not enough to accommodate the harvested water, huge volumes of water flow out of the pools to Al Fuhais valley and cause a lot of damage to the surrounding area. Water harvested is about 800 m^3,	Investigation of the surrounding area showed that two abandoned quarries with little improvement can be used to collect runoff water. Estimated amounts of water that can be harvested based on surveys is about 147,000 m^3 which is a huge amount of water.
Water awareness	The field visits revealed lack of water awareness among workers which resulted in wasting large amounts of water.	Water awareness program should start as follows: 1. Through the general safety unit, 2. Installing water saving devices in the housing and in the factory, 3. Initiate cooperation between the Ministry of Water and Irrigation and the factory which can help support the factory's awareness program through awareness workshops and educational material about water savings, **4.** Link the school at the factory to MWI water club for students,

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