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A prototype study for the management of surface water resources, Lebanon

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Abstract

Lebanon depends primarily, for its water resources on ground water that is deteriorating rapidly. The increased demand on water resources in Lebanon as a result of: progressive urbanization, socio-economic growth, development of agricultural and industrial activities will lead to critical water limitations factor by the year 2010. Consequently, other resources such as the availability of surface water in terms of quality and quantity is of major importance. The political instability in the country limited the development of a comprehensive data-base for surface water. The paper focuses on assessing the water quality of the Qaraaoun reservoir, an impoundment of the river Litani for multipurpose utilization. This would serve as a prototype for the development of comprehensive plans for optimal utilization of surface water sources in Lebanon, as a venue to meet the water needs of Lebanon. The Qaraaoun reservoir, which till now has limited utilization of hydroelectric power and agricultural activities, proved to posses other usage. A master plan for the management of the Qaraaoun reservoir, as a prototype for surface water, should address policy constrains relative to environmental, institutional and financial issues. © 2001 Elsevier Science Ltd. All rights reserved.

1. Water demands in Lebanon

The increased demand on water resources in Lebanon as a result of progressive urbanization, socio-economic growth, projected developments in the agricultural and industrial sectors has been posed as a major factor for the envisaged problem related to water availability by the year 2010.
At present, policies and plans addressing long-term water needs are focusing on the use of non-conventional water resources demand such as ground water recharge, rain harvesting and desalination. Minimal attention is directed towards protection and promotion of surface water in terms of qualitative and quantitative availability. At present, Lebanon depends primarily on groundwater that is becoming less available due to its rapid deterioration in quality through continuous exposure to various sources of pollutants and possible saline intrusions along its populous coast (Jurdi, 1992, 1998; Khair, Aker, Haddad, Jurdi, & Hachach, 1994; Sene, Marsh, & Hachache, 1999). Lebanon in comparison with neighbouring countries in the region (Syria, Jordan, Israel, Egypt, Cyprus, Turkey) receives relatively higher levels of rainfall, 823 mm annually and reaches 1400 mm in high mountains (Khair et al., 1994; Sene et al., 1999). Most rainfall occurs within a limited period of 80–90 days during the rainy seasons extending between the months of October and April. This major source of surface water in the country which is highly exposed to contamination due to the improper management of sewage, industrial wastes and municipal solid wastes that are disposed into watercourses without any type of treatment (Jurdi, 1992, 1998). This problem of surface water is aggravated by the lack of hydrometric data in relation to the operational forecasting of water shortages and flood events, due to civil war events (Sene et al., 1999) and surface water quality data basis. The lack of these data hinder programs that are directed towards the utilization of these resources. Consequently, a solution to future water demand through optimal utilization of surface water should be of major concern.

This presentation focuses on assessing the water quality of the Qaraaoun reservoir, an impoundment of the river Litani for multipurpose utilization. This would serve as a prototype for the development of comprehensive plans for optimal utilization of surface water sources in Lebanon, as a venue to meet the water needs. The choice of the Qaraaoun reservoir as a prototype for the comprehensive management of surface water is based on the fact that the river Litani is the longest (170 km) and the largest river in Lebanon. The average annual discharge rate is 770 million m$^3$ (UNDP, 1970; Mudallal, 1989; Beschorner, 1992). The river’s source is the Al-Oliek spring in the Bekaa Plain (west of Baalbeck), it flows southward parallel to Mount Lebanon and discharges into the Mediterranean Sea 7 km north of Tyre. Geomorphologically, the Litani basin is divided into three sub-basins, the largest is the upper one stretching from the Bekaa Plain to Qaraaoun Dam, which was built in 1958–1965. The Dam is 110 m long and 61 m high forming the Qaraaoun reservoir that can store up to 220 million m$^3$ of water of which 160 million m$^3$ are used annually (for irrigation and hydropower) and 60 million m$^3$ remain in storage over the dry seasons (Khair, 1993; Owaydah, 1993). At present, utilization of this water body is limited to irrigation and power production. The prime objective of the present study is the feasibility of Qaraaoun reservoir for multipurpose usage (domestic, agricultural, recreational and industrial).

The ultimate objective is proposing a recommendation for the need of proper management of these water bodies for multipurpose water utilization.

2. The Qaraaoun reservoir

The assessment of the water quality of Qaraaoun reservoir, for multipurpose utilization, was based on a study conducted during the dry season (13 July, 2 August, 26 September and
6 October, 1995) on 18 sampling sites through their variation in the physical, chemical and bacteriological concentrations. The determinations of these parameters were in accordance with standard methods set by APHA, AWWA, WPCF (1992) and US EPA (1999). The results reflected the existence of three environmental water quality zones within the reservoir: Zone (I), the receiving zone whereby contaminants from the Litani river are pooled in and these lead to maximal fluctuation in water quality. Zone (II), the stable zone, that exhibited minimal fluctuation in water quality resulting from the high turbulence of water that enhanced the chemical and biochemical oxidation processes and as such water self-purification was evident by the stability in the analytic values. Zone (III), zone near the constructed dam, the dam itself induces sediment deposition and reduces turbulence resulting in fluctuations in water quality (Jurdi, Korfali, Karahagopian, & Davis, 2000). Accordingly, the stabilized zone (Zone II) would be the choice for water extraction for the multipurpose utilization of the Qaraaoun reservoir and its suitability was investigated based upon comparing the water quality with the guidelines and standards of respective usage. Results indicated no restriction on use for human consumption, as long as the water is subject to sand filtration and disinfection processes following the guidelines of national primary and secondary drinking water regulations (US EPA (1999), WHO (1996) guidelines and EEC (1980) standards). Besides, the suitability of the Qaraaoun reservoir for supplying irrigation and livestock water was in compliance with the recommended guidelines (Ayers and Wescot, 1985). This emphasizes the importance of this resource in elevating Lebanon current water shortage. In addition, the suitability of Qaraaoun Reservoir water for fish breeding was acceptable according to the fisheries guidelines, (US EPA, 1986; Harvey, 1989). This would be a potential solution to fish availability in Bekaa valley primarily and in Lebanon. Lebanon consumes 25,000 t of fish per year of which only 2500–3500 t come from coastal Lebanese fisheries despite the long Lebanese coastline, which extends over 220 km along the Mediterranean Sea. The low yield of Lebanon marine fish supply arises from primitive fishing methods, waste dumping and use of dynamite for fishing (Faour, 1992) makes seafood an expensive luxury. Whereas, the suitability of Qaraaoun reservoir for recreational activities (swimming, water skiing, fishing and boating) as indicated by WHO and AWWA guidelines would enhance the development of tourism and associated socio-economical development of the area. However, continuous monitoring of the microbiological quality of the Qaraaoun water is necessary to ensure compliance. Further, the suitability of utilization of Qaraaoun reservoir for industrial purposes partly meets the water demand of local industries (electrical supplies, food, dyeing and tanning and paper products) as recommended by the respective industrial guidelines (Sherrard, Moore & Dillaha, 1987; AWWA, 1990; Degremont, 1991). Consequently, this would reduce the exploitation of ground water resources that is being deteriorated in quality as a result of over-pumping, primarily in Bekaa valley (Guillaume, 1999).

3. Integrated management of water resources

The prototype study of the Qaraaoun reservoir confirms the need to implement an integrated approach for the management of water resources. The integrated management of water resources
in developing countries, such as Lebanon faces major hindering factors relating to the following factors:

1. Environmental constraints.

3.1. Environmental constraints

Environmental impact assessment should be considered as an integral component of any proposed management plan. This is clearly indicated for the presented prototype of the Qaraaoun reservoir. Development of a water plan should address the critical, identified environmental issues of proper management of municipal domestic wastes, hazardous industrial wastes and sewage. These factors were identified by our previous studies that included surface mapping of the Litani River and Qaraaoun reservoir. In addition, the characteristic of the geological limestone basin were identified in correlation with the over all assessment of the water quality (Jurdi et al., 2000). Besides the health impact of such projects should become an integral component of the environmental impact assessment.

3.2. Methodological and databases constraints

The prototype study confirmed the need for assessing and developing water data basis to question suitability of such resources for multipurpose utilization. Ambiguity relating to types and sources of contaminants play a major role in limiting utilization of surface water as a potential resource to meet water demands. The Qaraaoun reservoir, which till now has been limited in utilization to agricultural and hydroelectrical power use when assessed proved to be suitable for drinking, fisheries, recreational and industrial uses. The development of set methodologies for the establishment of a comprehensive data base for surface water would determine the availability of resources, qualitatively and quantitatively, to meet water demands as part of the comprehensive-integrated management of water resources within a country.

3.3. Institutional, legal and financial constraints

The development of water data basis should be institutionalized to provide continuous monitoring for evaluation and sustainability of projects. This requires aside the existence of physical facilities, promoting human resources. Institutionalization as part of the integrated management of water resources is critical to promote co-ordination between different assessment groups and programs, thus, pooling resources and resolving part of the needed financial burden. Besides, this would aid in developing and implementing programs that are economically and socially effective and efficient. Last but not least, development and enforcement of sound environmental rules and regulations has a critical impact on the implementation and sustainability of water projects. At present, these limiting factors are hindering directing water projects in the country.
4. Conclusion

The study of Qaraaoun reservoir conferred the need for assessing and developing of water data basis to question suitability of such waters for multipurpose utilization. Ambiguity relating to types and sources of contaminants can play a major role in limiting utilization of surface water as a water resource. In addition, our studies confirmed that once data-basis are established, continuous monitoring and evaluation would be the key element in maintaining sustainability. Besides, comprehensive integrated management plans should address development and enforcement of environmental rules and regulations.

The proposed prototype does not apply to Qaraaoun reservoir only as a number of dams are being proposed for constructions. Development of a master plan for the management of the surface water sources, should be an integral component of projected policies to meet water demand and enhance socio-economical development.

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