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Evaluation of the Wastewater-Related Problems of Shoteit River in Shushtar (Southwest Iran)

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Abstract: The primary objective of the present study was to evaluate the polluting sources and inflow of the Shoteit River and offer several practical solutions to reduce such contaminations. Therefore, it is essential to determine the polluting load of the inflowing wastes to the River. The polluting sources of Shoteit River can be divided into three sectors including agricultural, industrial and urban. Contaminants were identified and the polluting load was calculated accordingly. The total annual pollution load flowing into Shoteit River from the cities of Shushtar and Gotvand includes 1539 t of BOD5, 4493 t of COD and 8071 t of TDS. The result of present study, as expected, showed that most pollution of Shoteit River environment is caused by agricultural wastes having a higher discharge compared to the wastes produced by the two other sectors. Industrial polluting sources have the second largest polluting load to the Shoteit River. The urban polluting sources are in the third position. It should also be noted that solid wastes affect the pollution state of this River. After analyzing the data, several practical solutions are proposed to alleviate the problems caused by polluting inflow to the River. Alternatively, constructed wetlands can be used for primary treatment, where the wetland is the only type of treatment used and in this case, toxic effects on the aquatic plants due to the high organic loading of the influents have been reported.

Key words: Reducing contamination, pollution load, agricultural drainages, industrial pollutions, urban pollutions, discharge, wetland

INTRODUCTION

Water is one of the limiting resources in achieving sustainable development especially when the limitations are considered to be a serious threat to the quality of water (Economopoulos, 1993) Introduction of pollutants to the food chains, threatening consumer health, reduction of the crop yield and the like, are only a few of the hazards to the water resources. Attaining pollutant-free water is a hard work that requires huge spending and efficient management. Thus, the most effective solution of reducing the environmental pollution is prevention and before deciding on any practical technique it is required that the pollutants and their origins be realized as a priority. Shoteit River is the most critical environmental element in the region that contribute largely to the production of agricultural crops especially sugarcane (Fig. 1). Considering the fact that this River is one of the main tributaries of Karun River, thus its contamination can create problems to the users downstream especially residents of Ahwaz. This River is currently receiving a huge portion of urbane, industrial and agricultural wastewater (Fig. 2-4). The total annual pollution load flowing into Shoteit River from the cities of Shushtar and Gotvand include 1539 t of BOD5, 4493 t of COD and 8071 t of TDS. Constructed wetlands are gaining importance as an effective and low-cost alternative for treatment of

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Fig. 1: A photo of Shoteit River

Fig. 2: Shushtar urban wastewaters discharged to the Shotiet River

septic effluents in small villages. Such systems have certain advantages over the conventional treatment systems: they can be established in the same place as where the wastewater is produced; they can be maintained by relatively untrained personnel; they have relatively lower-energy requirements and are low-cost systems. These wetlands are usually utilized as secondary and even as tertiary treatment (Stober *et al*., 1997; Billore *et al*., 1999; Neralla *et al*., 1998).

Alternatively, constructed wetlands can be used for primary treatment, where the wetland is the only type of treatment used and in this case, toxic effects on the aquatic plants due to the high organic loading of the influents have been reported by Gersberg *et al*. (1986) and Haynes and Goh (1978). Mitsch *et al*. (2005) described the development of vegetation succession in relation to hydrology and nutrient retention in created Riverine wetlands over a 10-year period. The use of surface flow constructed wetlands for the treatment woodwaste leachate in British Columbia is discussed by Masbough *et al*. (2005). The system showed promising treatment effect but climatic conditions affected the performance and adjustment of pH is desirable. Also, the results indicate that treatment

Fig. 3: Industrial wastewaters channel of sugarcane project discharged to the Shoteit River

Fig. 4: One of agricultural lateral drainage wastewaters discharged to the Shoteit River

performance improves with the length of operation Surface flow constructed wetland plant species composition management is discussed by Thullen *et al*. (2005). It has been found that the proper vegetation management not only improves treatment effect but also improves substantially wildlife value of the constructed wetland, Headley *et al*. (2005) described effect of depth and vertical mixing within a horizontal sub-surface flow wetland on removal of various pollutants. The results indicate that there is no benefit in increasing the bed depth beyond the standard 0.5 m and that shallower beds may in fact perform better. Salahshour and Fakour (2005) in their study determined the causes of the Rood-eShoor salinity in Batvand and investigated the possibilities of application of its water for agricultural purposes. This study revealed that by separating the water inflow of the saline springs into the Batvand River the water quality can be preserved considerably.

MATERIALS AND METHODS

The present study was conducted in Shoteit River sub basin, Khuzestan Province, West of Iran during Feb-Nov 2007. The study area is located 64 km southwest- 20 km Northwest the city of Shushtar, 48 50 E and 32 03 N to 48 52 E and 31 38 N with 84 km length. Shoteit River is one of the two main branches of Karun River that firstly joins Bnd-e Ghir at the beginning of Dez River and then flows into Gar-Gar River forming the Great Karun. This river extends from 48 50 E and 32 03 N to 48 52 E and 31 38 N with 84 km length. The present study uses the results of samples taken by Khuzestan water resource investigation office (2002) from different wastewater discharges on monthly and yearly basis. A standard evaluation method (Andrew *et al*., 2005) was used to evaluate the samples in which the total pollution was determined after multiplying the quantities of contaminants inflowing to the River and measured discharge flow by a pollution load constant. The experiment that was conducted are, River discharge flow (by using mollineh method), measurement of chlorine, nitrate and phosphorous (by titration method), biochemical oxygen demand (BOD-by oxidation method), chemical oxygen demand (COD-by K_2MnO_4 method), dissolved oxygen (DO-by oxidation method and dissolved oxygen probe), total suspended solids (TSS-by filtration method) and total dissolved solids (TDS-by Conductivity meter method). A dependable bioassay method developed by Chou *et al.* (1978) to assess the level of phytotoxicity of polluted water. Samples of polluted had collected from six different points on the River Damodar, the Barrage Reservoir and Tamla, a rain-drain turned into an industrial waste channel ending in the Damodar. A number of plant species were used at a time as test material for assessing phytotoxicity and the average value was taken as index of pollution level. A cardinal feature of the technique was that no previous knowledge of the pollutant was needed and therefore no preconceived notion could interfere. The method had further extended and elaborated in the Department of Botany, Visva-Bharati by adding cytological observations (Ray and Banerjee, 1981) to those on radical growth. Cytological studies not only indicated the intensity of the effects of pollution but could even indicate the class of chemicals responsible for the damaging effect.

The nature of intracellular damage served as a good indicator in this respect (Ray, 1987). Yet another set of experiments in the field and the laboratory clearly established the ability of water hyacinth to tolerate pollution and absorb pollutants quickly and to a remarkable extent (Ray and Saha, 1992; Gopal and Sharma, 1981). These properties of water hyacinth can be easily used for reducing toxicity of diluted effluents and removal of heavy metals.

RESULTS

Sources to Shoteit Pollution

The main sources to Shoteit pollution include a part of Shushtar urban wastewaters (Table 1). Based on the recent statistics, more than 96370 people are living in this city whose water consumption amounts to 37840 m^3 and urban wastewaters producing 30272 m^3. The agricultural wastewaters of 266 m^3 related to small- and large-scale units mostly used in sugarcane production in Sardar Abad area discharge into this River. Also, a portion of the wastewaters generated by Irrigation and Drainage Networks of the Greater Karun, covering an area of 32290 ha. Between Shoteit and Gar-Gar River flows into Shoteit River. Annually, 2576170 kg of BOD, 12880620 kg of COD, 22400050 kg of TSS, 12877720 kg of Nitrate, 183400090 kg of sulfate, 73359890 kg of Choler and 257670 kg ammonium

Table 1: Shushtar wastewaters polluting load discharged to the Shotiet River (kg day^{-1})

Urban wastewaters parameters	BOD5	TSS	TDS	NO	Total P	Cl	COD	NH	Wastewater discharged (m^3 day^{-1})
Shushtar city	1277	2333	12349	61	39	3969	2747	241	9

Table 2: Industrial wastewaters load discharged to the Shoteit River (kg day^{-1})

Industrial nitrate wastewater	Cl	NH	SO	DO	BOD5	TDS	TSS	Total P	Org. P	COD	Total N	Org. N
Karun sugarcane project	19527258	237	22332	601	3032	80846	8290	7	4	2643	229	83

Table 3: Agricultural drainage wastewaters load discharged to the Shoteit River (kg day^{-1})

Drain	DO	DOD5	TDS	TSS	Org. P	Total P	COD	NH	SO	NO	Total N	Cl	Wastewater discharged (m^3 day^{-1})
Karun sugarcane project	5226	6775	1119461	58385	22	68	57773	1101	480889	3381	1877	192046	734

are discharged into Shoteit River that are produced by Karun Sugarcane Drainage Network (Table 2, 3). Hossini (2002) conducted a study to evaluate the pollution state of Karkeh River. The result shows that annually, 2346154 kg of BOD, 11562840 kg of COD, 18867914 kg of TSS, 9978463 kg of Nitrate, 165721489 kg of sulfate, 64962741 kg of Choler and 215847 kg of ammonium are discharged into Karkeh River that are produced by agricultural, industrial and urban sectors.

DISCUSSION

According to the aim of the study, solutions for the wastewater-related problems of shoteit river, solutions can be categorized into three groups, Direct, Indirect and Supportive schemes, that all of these groups leads to reduce Agricultural, Industrial and Urban pollutions. The following practical solutions can be considered in reducing the pollution of Shoteit River after analysis of the data and information obtained.

Direct Projects

These projects include those that by their execution the amount of River pollution are reduced directly and immediately. The followings are examples of such projects in urban wastewater projects:

- Development of urban wastewater collection and treatment facilities in Shushtar
- Separation of hazardous sanitary wastewaters
- Prevention of any urban wastewater discharges into Shoteit River

According to the research done by Mehrotra (1990), the various sources responsible for pollution of the river in Varanasi city are domestic sewage effluents of the industries, burning of dead bodies at the ghats, use of detergents, insecticides and pesticides used in agriculture. Study revealed the presence of toxic metals like mercury (65 to 520 ppb), Lead (less than 10 to 800 ppm), chromium (less than 10 to 200 ppm) and nickel (less than 10 to 130 ppm) in the sediments of Ganga river at Varanasi city. In 1982 drought conditions prevailed throughout the year and the level of phytotoxicity did not show significant seasonal variation either in the Barrage Reservoir or in Tamla water. The striking feature was that moderate rainfall in monsoon increased toxicity in the Barrage Reservoir water and to a still greater extent in Tamla water. This result can be explained if we consider the nature of the catchment area concerned (Ray and Banerjee, 1984). The Cu, Co, Zn, Ni, Mn and many other metals passing from industrial waste into water and soil, attain higher concentrations and accumulate in dangerous quantities in different plant parts and finally pose serious health hazards to human beings and domestic animals through biomagnifications. The quantity of the different trace metals was found to be often considerably higher in the plants than in the polluted soil and water (Ray, 1990).

Direct projects in agricultural and industrial sectors are mostly aimed improving agricultural management in reducing the pollution resulting from pesticides and fertilizers. This is in accordance with the results gained by the study made by Paliwal et al on the quality of the river Yamuna in India. That study revealed that it was necessary to treat the discharge from drains to the river Yamuna and diversion of a substantial load to the river for further treatment was also essential (Paliwal *et al*., 2007).

The following are examples of direct projects in agricultural and industrial sectors:

- Improvement of cropping and irrigation patterns
- Less use of hazardous pesticides and fertilizers
- Separation and diversion of agricultural drain
- Treatment and reuse of agricultural drain

Modern agriculture depends on chemical fertilizers, pesticides and irrigation to produce high-quality crops for animal and human consumption. To maximize the crop yield, nitrogen-based fertilizers are spread on the land. In addition, phosphorus and other essential minerals also may be applied where they are lacking or have been depleted in the soil. To improve production, herbicides to kill weeds and insecticides to kill insects are frequently applied to croplands. Not all of the fertilizers and pesticides stay where they are applied; consequently, some are released to the atmosphere, seep into groundwater, or are carried to lakes and streams by runoff, where they may create pollution problems. Reducing pollution load resulting from solid wastes (Dodds, 2002).

Solid wastes also play a key role in Shoteit River pollution. The following projects can be considered in this regard:

- Recycling and reuse of by-products of different production processes
- Standard burial of industrial solid wastes and prevention from their seepage

Considering urban solid wastes, the seepage of the wastes can affect the Shoteit River pollution along with direct discharge of the wastewaters into the River and the following practices can be considered:

- Improvement of collection and burial of urban wastes
- Development of waste recycling scheme
- Suitable burial of infected wastes
- Reduction of water uptake from Shoteit River

Any reduction in water uptake along with a decrease in water consumption can reduce wastewater production and prevents soil and water resources contamination. The following schemes can be executed in the urban, industrial and agricultural sectors to reduce the water uptake at Shoteit River:

- Using groundwaters instead of River water
- Reusing wastewaters after treatment

Indirect Schemes

Indirect schemes include those that their execution has "indirect" effects on the reduction of River pollution. These schemes can be focused on the following objectives:

- Reduction of pollution concentration in industrial wastes
- Controlling discharge wastewaters into Shoteit River

- Development of urban infrastructure
- Other schemes

Controlling Discharge Wastewaters into Shoteit River

The water use and consequently the wastewater produced can be controlled in agricultural and industrial sectors by improving the existing irrigation schemes.

Development of Urban Infrastructure

By developing schemes with the aim of improving water supply systems and separation of drinking and non-drinking water supply systems the set objectives of this practice can be achieved.

Other Schemes

Privatization of the irrigation networks, developing rural water supplies and integration of farmlands in the region are among the considered schemes in agricultural and sugarcane industry in the area. In the urban sector, schemes such as improvement of urban landscape cropping and irrigation and developing frostily are proposed.

Supportive Schemes

Indirect schemes provide the basic data and potential research fields to execute the broad-based scheme of water resources pollution reduction plus supervision, evaluation, control and improvement of the schemes.

The proposed schemes include:

- Establishment of monitoring and sampling network
- Structural and legal adjustments
- Behavioral changes and human resources capacity-building
- Supervision and evaluation
- Developing science-based perception

Establishment of Monitoring and Sampling Network

Quantities-qualitative monitoring of water is based on developing data required on quantity, physical, chemical and biological properties of water by its sampling. Sampling and monitoring provide required data for effective management and operation of any system. Considering the properties of Karun and Dez basins the following schemes are suggested with the set objectives:

- Developing monitoring network for chemical properties of groundwaters, River and discharged wastewaters
- Identification of unauthorized discharging units
- Supervising industrial wastewaters discharge and quality
- Establishment of monitoring network for chemical properties of groundwaters within farmlands
- Establishment of monitoring network for drained wastewaters discharged into Shoteit
- Control and supervision of urban discharge and quality of wastewaters
- Effecting the Pollution Tax scheme
- Establishing environmental departments and units in all the related organizations and entities

Structural and Legal Adjustments

The proposed schemes include:

- Establishment of environmental control unit
- Preparation of industrial construction within River's boundaries

- Setting out local regulations for industrial wastewaters
- Setting out deadlines for industries discharging wastewaters with a lower quality than standardized quality
- Providing standard cropping patterns
- Supervising the use of proposed cropping patterns with the standard patterns
- Providing time schedule for different crops and land leaching
- Non-issuing of legal permits to discharge wastewaters into the River
- Preparation of urban construction regulations
- Setting out legal limitations for those who pollute water
- Verification of wastewater discharge system before construction of residential buildings

Behavioral Changes and Human Resources Capacity-Building

The proposed schemes in this section include:

- Completion of facilities and training of the managers and engineers
- Preparation of environmental training plans for managers and decision-makers
- Providing training plans for local farmers
- Providing educational publications, movies etc regarding River pollution to educate local farmers
- Training managers on waste burial and discharge techniques
- Public education on the impacts of water pollution

Supervision and Evaluation

The pollution control and environmental conservation system includes several schemes and sub-schemes where each of them focuses upon one of the aspects of the environmental pollution. This system is consisted of interrelated components that are uniquely complex in nature and supervision and evaluation plays a key role in performance of different activities. Supervising and evaluating helps rating and scoring accurately the performance of the system components and the priorities are then determined for each of them. Characteristics and possible challenges for each will be determined and the product is a control system that continues to self-improve to reach the set objectives in prospect.

The objectives are achievable through following schemes:

- Verification of environmental schemes before execution environmental impact evaluation standards
- Environmental auditing based on economic perspectives
- Supervision and evaluation of all pollution reduction schemes during execution and operation
- Verification of urban development project before execution

Developing Science-Based Perception

Preparation and execution of any comprehensive pollution prevention plans requires basic researches, state-of-art technology and advanced management practices. Basic researches provide fundamental data and information for designers, improvement of various alternatives and evaluation of positive and negative aspects of the schemes.

The proposed schemes in this field are:

- Preparation of qualitative and quantitative operational instructions
- Development of research and academic projects regarding quality of Shoteit River
- Establishment of qualitative and quantitative data bank
- Conducting required studies for determining efficient crop patterns
- Conducting required studies for efficient irrigation

- Conducting required studies for agricultural wastewater transition
- Studying types and quantities of polluting toxins in Shoteit River
- Studying interactions of surface and ground waters within the scheme area
- Studying optimal water consumption management
- Preparation of efficient water consumption patterns

CONCLUSIONS

The aim of the present research was to investigate the polluting sources and inflow of the Shoteit River and offer several practical solutions to reduce such contaminations. In order to this issue, it is essential to determine the polluting load of the inflowing wastes to the River. The polluting sources of Shoteit River can be divided into three sectors including agricultural, industrial and urban. Contaminants were identified and the polluting load was calculated accordingly. The result of percent study, as expected, showed that most pollution of Shoteit River environment is caused by agricultural wastes having a higher discharge compared to the wastes produced by the two other sectors. Industrial polluting sources have the second largest polluting load to the Shoteit River. Saxena *et al*. (1966) made a systematic survey of the chemical quantity of Ganga at Kanpur. According to the study, the biological oxygen demand, i.e., BOD. Varied from 5.3 ppm (minimum) in winter to 16.0 ppm (maximum) in summer. He concluded that the tanneries significantly increased the pollution load of river as they discharge huge amounts of effluents containing organic wastes and heavy metals. It was further reported that forty five tanneries, ten textile mills and several other industrial units discharged 37.15 million gallon per day of waste water generating BOD load of approximately 61630 kg day^{-1}. And urban polluting sources are in the third position. Researchers conducted a study to evaluate the pollution state of Jarahi River. The result shows that polluting sources of Jarahi River are agricultural, Industrial and urban polluting, respectively. It should also be noted that solid wastes affect the pollution state of this River. After analyzing the data, several practical solutions are proposed to alleviate the problems caused by polluting inflow to the River. Finally, it seems that in Khuzestan province the results of these studies and/or researches nearly are similar to each other, the previous research showed the same results for Rivers polluting sources of Khuzestan province.

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