Procedure of a comprehensive water quality management in rivers

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***Abstract*—Nowadays, with the increasing effluent discharge into the rivers, the need for a proper quality management for controlling the effluent discharge is highly essential. If there is a regular procedure for water quality management, there won't be any interested decisions, overlapping, or management shortcomings. In this paper, a regulated procedure for the management of inappropriate quality conditions River has been offered. In this procedure, the important management key features such as considering the hydraulic conditions of the rivers even in their reach separations, the optimum usage of the self-purification characteristic of the river, calculating the total maximum load in the river, simulation and execution of the strategies in rivers using an appropriate model, and making a decision based upon the results of applying that strategy in the model according to economic, environmental, social and other criteria. Since this procedure is flexible and comprehensive, it will be extended to all of the rivers.**

***Keywords*—Water Quality, Effluent discharge, River, self-purification**

I Introduction

Clean, safe and adequate freshwater is vital to the survival of all living organisms and the functioning of ecosystems, communities and economies (Vieira et al, 2012). Increasing water scarcity together with decreasing quality is forcing developing countries into remediation options of river water quality. The assessment and evaluation of human impacts on the quality of surface waters have become the main objectives in river basin management (Barth 1998)

The prudent utilization of water resources has been an important issue in public policy for decades, and much effort has been expended in developing effective water management strategies to ensure sufficient high-quality water supplies (Eatherall et al. 1998; Elshorbagy and Ormsbee 2006; Horn et al. 2004; Ning et al. 2001)

Today, trial and error cannot be applied for selecting a proper strategy for water quality management of rivers. In fact, various management methods are executed with simulation models and final decision for a proper strategy can be made.

In line with this fact, several researches have been conducted in which different models and strategies have been applied. As an example, in a research by Kannel et al. (2007), three management strategies were simulated in Qual2k and the results indicated that the combination of wastewater modification, flow augmentation and local oxygenation is suitable to maintain the acceptable limits of water quality criteria. Also, Vieira *et al*. (2012) predicted the impact of flow conditions, discharges and tributaries on the water quality of Lis River using QUAL2Kw model and they proposed short-term corrective measures, as flow augmentation and discharges control, to improve the water quality in Lis River in order to achieve a healthy balance of the ecosystem.In the mentioned papers, a change in hydrological conditions of a river and increasing its self-purification capacity is emphasized as one of the water quality management methods of a river; however, it would result in high costs. Hence, in order for water quality management of a river without changing its hydrological conditions, it is required to adjust the loading capacity of the river according to its self-purification capacity based on climatic, hydrological and hydraulic conditions (Ministry of Energy, 2005).

In various papers, waste load allocation has been applied for water quality management of the rivers. Kerachian and Karamous (2005) and Murty *et al.* (2006) used optimization Genetics algorithm approaches, Mostafavi and Afshar (2011) applied Ant colony algorithm, and Sun *et al* (2013) used information entropy for waste load allocation. In this way, through various methods of optimization, they determined a removal fraction percentage to obtain a standard water quality by the least costs. Continuing this process, some researches such as one by Niksokhan and Kerachian (2009), applied several theories such as game theory to reduce and reallocate the treatment costs. In addition, Amirpor *et* *al.* (2010) used cooperative management approach for an optimized allocation, in a way that through applying Genetics algorithm, they found the best scenarios of cooperation among the waste dischargers of the system, which can lead to a noticeable saving in initial waste treatment or to increase the waste load capacity of the river system

Among the existing approaches of river quality management, selecting a comprehensive management method which considers all of the conditions such as the type and location of the river, climatic condition, the number of pollutant sources, the budget and the economic and social requirements of beneficiaries is the great importance. Additionally, applying a thriving management approach for several rivers is not rational, since a completely successful approach for one river might result in worst consequences for another river.

The issues that affect the management process include the location and the quality condition of the river, the number and the type of pollutant sources and their locations, the climatic conditions of the region, social and economic conditions, current status and an evaluation of future, and finally the execution assurance.

In order to regard these issues and to avoid shortcoming or overlapping, an exactly regulated program and pattern is required for a systematic continuation.

The purpose of this paper is to prepare a procedure to manage the quality of the rivers in critical conditions: considering the current condition of the river and the existing standards, a management method should be applied to resolve the critical condition of a part of the river which has exceeded the acceptable value of pollutants in the river's ecosystem. This management is conducted through codifying several scenarios which are simulated in river's quality models, and the results of this simulation can be compared to obtain the best scenario and strategy for the river management.

II Materials and Methods

In this paper, the procedure of an environmental quality management of effluent discharge into the river has been represented.

In this procedure, the principles and key features mentioned below are considered:

Considering the hydraulic conditions of the rivers

- Optimum usage of the river self-purification
- Considering the maximum allowable pollutant load in the river
- The importance of applying an appropriate model for simulating and executing the strategies in the river
- Decision-making according to the economic, environmental, and social criteria; and regarding the consequences of executing the strategies in the model

According to this procedure, first, the pollutant sources, waste load and concentration which are discharged in each part along the river are identified. Then, through a general knowledge about hydrological and topographical conditions of the river, the river is divided into several segments based on the hydraulic features, physical features such as slope, width, and roughness of the river's bed, and reaction coefficients such as CBOD Extinction coefficient, reaeration and oxidation, in a way that in the beginning of each segment, a measuring station be located. After entering the stations' data, pollutant sources and hydraulic conditions are calibrated to a simulating model of river's quality with change in synthetic coefficients, and the quality conditions of the river are simulated. After the simulation of the quality conditions of the river, the segments in which deviates from the standard value are identified as critical segments, and the waste load which exceeds the threshold of self-purification capacity of the river and causes the critical situation is calculated by the model. Afterwards, this calculated value is allocated among the pollutant sources, regarding various allocation methods through different management scenarios. In the following, the best scenario can be selected with respect to some criteria such as social features-justice and acceptance of related societies-, economic features-treatment cost-, environmental aspects and so on.

After the executing of the selected strategy, an annual supervision is required, because the development process might have added new pollutant sources leading to a need for changing or modifying the selected scenario.

These stages have been represented below:

1. A general knowledge about the studied river and gathering hydro-geological data
2. Segmenting the studied river based on the hydraulic conditions and self-purification characteristic of the river
3. Selecting the sampling locations and measuring the quantity and quality parameters of the river in way that one station should be located in the beginning of each reach.
4. Identifying of the pollutant sources and amount of their load in each reach
5. Entering all of the data such as the data of point and nonpoint source loadings, the measured data, and the hydraulic characteristics of the river into the water quality simulation model
6. Calibrating the model and execution
7. Determining the critical points and reaches in the river, and determining the acceptable

pollution load in each reach considering a safety factor and uncertainty

8. Preparation and execution the management scenarios to reduce the pollution load among the pollutant sources in separated reaches and different seasons

9. Selecting the best management scenario according to the environmental, economic, industrial, and social criteria, preferably applying the optimization models

10. Execution of the scenario for removing

11. Supervision, monitoring, and making the required modifications

In the following some stages needed to explain would be explained

III Selecting the appropriate model

Simulation models are those utilized to estimate a system's behavior. These models cannot directly choose management alternatives according to constraints. Also, simulating is performed in the form of different scenarios and the outputs are applied to manage systems. These models are highly practical in water quality management of aquatic systems (Mesbah, 2008; Ashegh Moalla et al. 2013)

some simulation models like QUAL2E, QUAL2K, and WASP4 are available to simulate the transport and fate of a number of quality constituents such as temperature, pH, carbonaceous BOD, DO, phytoplankton, bottom algae and several forms of the nutrients phosphorus and nitrogen in the river systems (Mostafavi and Afshar, 2011)

Selecting the appropriate model depends on the purpose of studies and that specific project. The best criterion for selecting a model is selecting the simplest one which has a high functionality in that specific case (Miri, 2009).

IV Uncertainty and Margin of safety

Considerable is usually inherent in estimating loading from nonpoint sources, as well as predicting water quality response. The effectiveness of management measures in reducing loading is also subject to significant uncertainty. When using models, either to predict loadings or to simulate water quality, managers should address the inherent uncertainty in the predictions. Various techniques for doing so include sensitivity analysis, first-order analysis, and Monte Carlo analysis. (USEPA. 1999) If relatively rapid growth is forecasted for an area, then it is recommended that some fraction of the maximum allowable load be placed in reserve for future growth. A fraction of the maximum allowable load can be set aside explicitly, or implicitly, as a margin of safety to account for scientific uncertainty. This uncertainty can be caused by insufficient or poor-quality data or a lack of knowledge about the water resource and pollutant effects. Thus, if a margin of safety of 0.8 is chosen, then 20 percent of the allowable load is placed in reserve (USEPA. 1997) the margin of safety accounts for the uncertainty about the relationship between pollutant loads and the quality of the receiving water body. The results of the uncertainty analysis performed for any modeling predictions can be factored into the decision regarding a margin of safety. (USEPA. 1999) Table 1 lists several approaches for incorporating margins of safety

TABLE I. APPROACHES FOR INCORPORATING MARGINS OF SAFETY (USEPA. 1999)

Type of MOS	Available Approaches
Explicit	• Do not allocate a portion of available loading capacity; reserve for MOS
Implicit	• Conservative assumptions in derivation of numeric targets • Conservative assumptions in loading and transport rates • Conservative assumptions in the estimate of control effectiveness

V Management scenarios

In order to eliminate the crisis in critical segments, Different ways of managing for reducing additional loading among existing pollutant sources along the river, were written as scenarios. Regarding the facilities, technology, and the economic, social, political, and environmental conditions of each region, different measures would be taken to compare and select the most efficient one through codifying them as scenarios and check them out in a model. The purpose of all of the scenarios was achieving a qualitative standard

VI Selecting the best strategy

In order to select the best strategy, there are several approaches such as utilizing optimization methods; a multi-criteria decision-making based on the social, economic, and environmental criteria…

After calculating the score of scenarios in each of the economic, environmental, and social criteria, a final score for each scenario would be obtained through merging the scores regarding the weight of each criterion. In weighting the criteria, the impression of experts is required.

VII Monitoring

After the execution of the selected scenario, even in case of being currently beneficial, there is rational need to make annual supervision and monitoring on the case, because there might be several new pollutant sources added due to the development process, it would be required to change or modify the selected scenario.

VIII Conclusion

The management methods and decisions should be in a wisely regulated framework and procedure to remain immune from the paradoxes, shortcomings and overlapping. The purpose of this study was to preparing a proper procedure for effluent discharge into the rivers which has considered the following issues:

1- The pollution capacity of a river should be proportional to its self-purification capacity according to the climatic, hydrological, hydraulic characteristics of the river.
2- It should have considered the benefit of beneficiaries and authorities through multi-criteria decision-making.
3- It should have applied an appropriate model of quality simulation to avoid the waste of time, and try - error.
4- Being comprehensive, it should be extendable to other rivers.

According to this structure, primarily, the quality and hydraulic data of the specific river in the critical conditions should be gathered, and after determining the ranges and validating the data, these data and waste water characteristics should be utilized as an input to the model. The final purpose is to execute the quality simulation model of the river after the execution of different scenarios to select the best method for developing the river’s condition by considering all of the aspects and characteristics of the river. Regarding social conditions, the selected method should be feasible with the least cost and least deviation from the quality standards of the river.

This procedure can be utilized for all of the rivers; however, based on the location and the conditions of the river, the details of the procedure would be different. Moreover, considering the nature of pollutants, a more appropriate model can be applied to better simulate the quality condition of the river. Furthermore, by evaluating the necessity of the problem and different influential factors, the best approach for the quality management of the river can be performed. However, all of the mentioned points should be respected in a regulated framework to prevent disorder in the route of management.

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