Water Quality Trading Using Tradable Discharge Permit in a River and Assessment of Its Cost-Effectiveness

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Received: Sep., 2007 Accepted: July, 2009

Extended Abstract
Localizing water resource management with optimum waste allocation approach in rivers is one of the strategies for reducing the pollution. In this regard, a water quality trading program among pollution sources can fulfill this issue. This program is achieved through a tradable discharge permits system which is based on the river self purification capacity and creates an economical incentive to reduce the pollutants. Water quality trading emerges from the concept of hydrology and economy based on the transfer coefficient which is the fraction of pollution load that is transferred from the upstream to the downstream. Transfer coefficient is obtained from the water quality model. In this paper, execution of a tradable discharge permit program for the index pollutants has been assessed. Finally the results are analyzed for evaluating the cost effectiveness.

Materials and methods
Generally, a water quality trading program is executed through a five step procedure as follows:
1. Zoning the study area: Based on morphological, pollutants and dispersion characteristics of the river, the study area along the river is divided to a number of zones.
2. Determination of permissible load of each zone and the primary allocation of pollutant load:
Allowable BOD load of each zone is determined by applying the Streeter Phelps model
3. Transfer coefficient among the pollutant sources and defined zones.
Transfer coefficient (a_{ij}) as in Equation(1)is the share of discharger (zone) i (L_i) in the pollution of zone j (L_j)

$$a_{ij} = \frac{L_j}{L_i} \quad (1)$$

The coefficient is determined using the water quality model.

4. Calculation of Tradable discharge Permit (TDP) for each zone

According to the Equation 2, TDP for each zone is calculated:

$$TDP_j = E_j - \sum_{k=1}^{j-1} a_{kj}.TDP_k \qquad ,k < j \quad (2)$$

where:

TDP_j = Tradable discharge Permit (TDP) for zone j

E_j = allowable load out of zone j

a_{kj} =transfer coefficient of zone k at upstream of zone j

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5. Cost of pollution control: To evaluate the cost effectiveness, the cost of pollution control is calculated for technological and non- technologic control measures. In this study, the cost of treatment of one cubic meter wastewater is assumed 500 and 300 Dollars for industrial and municipal wastewater treatment respectively. The treatment plant lifetime is assumed 25 years old.Cost of trading plan implementation is composed of two sections: implementation and monitoring. These costs are estimated annually based on the type and the importance of the study area.

Case Study

The study area is a part of Dez river watershed between Dez dam and Ghir dam with the length of 153 kilometers.

Results and discussion

Based on the pollution sources and monitoring stations Dez River is divided to three zones as follows:

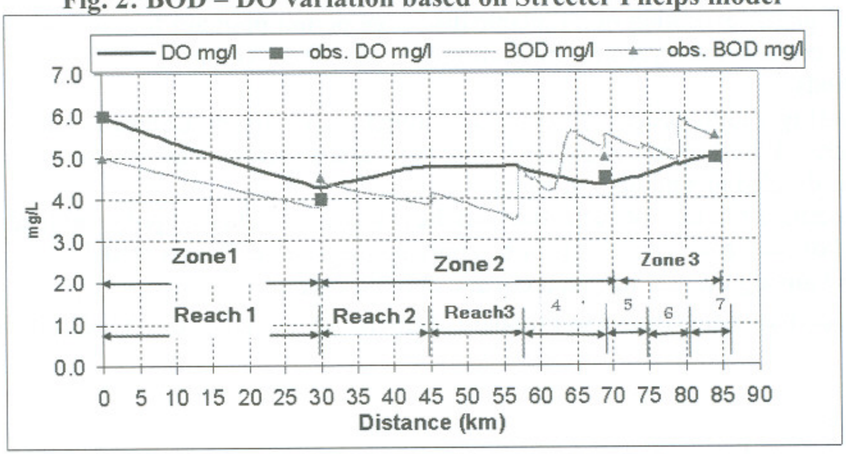
Zone 1: From Dez dam to downstream of Dezfool Ghand Company with the length of 44 km

Zone 2: From Dezfool Ghand Company to Abe shirin station with a 39 kilometer length.

Zone 3: from Abe shirin station to Ghir dam. The length is 15 kilometers.

The model of the river water quality has been developed based on the water quality variation and pollution sources along the study line. The river length is divided to seven regions and the model is calibrated according to the observed data. BOD and DO variation along the river is illustrated in Figure 2.

Fig. 2: BOD – DO variation based on Streeter Phelps model



According to the results, matrix of transfer coefficients between zones and pollution sources is demonstrated in Table 1.

Table 1: Matrix of transfer coefficients between zones and pollution sources

Zone	1	2	3
1	1	0.64	0.52
2	·	1	
3	0	0	1

According to the water quality standard, the allowable load of each zone is determined according to the results of water quality model. The TDP for each zone is calculated based on Eq 2. The results are presented in Table 2.

Table 2: Calculation of TDPs based on the allowable load of each zone

Zone	Source	Load (ton BOD/yr)	Allowable load of each zone (ton BOD/yr)	*Ej*	TDP (ton/yr)
1	Dezfool city	1896	474	1353	1353
	Ghand company	3515	879		
2	Andimeshk city	1780	445	3678.00	2812.00
	Haft Tape	5993	1498		
	Pars paper mill	6948	1735		
3	shoosh city	618	154	459.00	0.00
	Shoosh milk company	37	9		
	Karoon agro-industry	1183	296		

A comparison between technological (treatment plant construction) and non- technological (take part in the trading plan) cost of pollution reduction is compared in Table 3. The cost effectiveness of water quality trading plan is the ratio of technological to non technological cost of pollution reduction which is calculated and presented in Table 3.

Table 3: Calculation of TDPs based on the allowable load of each zone

Zone	source	Load reduction	non technologic control (C1)	cost of technologic control (C2)	C2/C1	Cost effectiveness
1	Dezfool city	1422	506	27,022	53	medium
	Ghand company	2636	938	19,699	21	very high
2	Andimeshk city	1335	475	13,693	29	high
	Haft Tape	4495	1599	61,013	38	high
	Pars paper mill	5206	1852	29,548	16	very high
3	shoosh city	463	165	6,601	40	high
	Shoosh milk company	27	10	164	17	very high
	Karoon agro-industry	887	316	20,562	65	medium

Conclusion

In this study the application of water quality trading has been demonstrated for the Dez River and the cost effectiveness of this method in pollution control has been assessed. The results show that implementation of water quality trading program is a cost effective method for municipal pollutants as buyer and industrial pollutants as seller. Also according to the cost reduction of supervision and monitoring and delay in satisfying the allowable load, this method is very beneficial and cost effective for the environmental authority. Generally the efficiency of this method is dependent on the number and amount of transactions in each zone of the study area. The most deals occur between the large pollutant as seller and small pollutants as buyer.

Key words

Technological pollution Control, Water Quality Trading, Discharge Permit, Transfer Coefficient, Cost Efficiency