THE APPLICATION OF GIS AND MODELS ON THE WATER BASIN MANAGEMENT – A CASE STUDY OF BERDAN RIVER

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ABSTRACT

The Berdan Dam supplies water to Mersin and Tarsus cities and is expected to supply water for 25-30 years. The protection of water quality is only possible by protecting and managing the dam and the basin which fits the dam. The management of such a system which contains a lot of parameters can be succeeded by using GIS. A GIS was constructed and numerical and thematic maps are produced for Berdan basin by Map Info. Water quality model was constructed by WQM-Cal and it has been determined that the waste water discharge does not cause any problem because of the flow rate oh the rivers in the basin being high.

The oxygen deficit was found to be only 1.4 mg/L and WQM has shown that there is not a critical day and oxygen content. The amount of phosphate coming from agricultural land use can create problems and especially after the rains the amount of pollutants is expected to increase. The eutrophication of the down was not modeled because the chlorophyll contents could not be measured. A phosphorus input modeling by WQM has shown that the phosphor level in the dam is critic.

Keywords: Mersin, Berdan, Water Quality Model, Geographic Information System.

INTRODUCTION

The sustainable management of water sources requires to protect both water quality and water quality. Taking in the consideration the quantity and quality of the basin makes it necessary to control a lot of parameters and this can be done by using GIS techniques. To determine the pollutants transported by the rivers and their accumulation in the dam water quality models should be used. The models are very frequently used for solving the water quality problems (Karim & Badruzzaman, 1999).

The Berdan dam located in the north of Tarsus is very important for Mersin and Tarsus cities. It has an area of 10.5 km^2. The dam is constructed on the Berdan River. The Tarsus river start at Namrun Plato on the south of Bolkar Mountains, and it meets Pamukluk rivulet of the Mutat Bridge. The Berdan River has a length of 124 km and it reaches the Mediterranean Sea in the south of Tarsus city. Its average flow rate is 42 m^3/s. (Republic of Turkey Ministry of Environment ve Foresty, 2004). The drainage basin of Berdan River is 1592 km^2. The area is mainly used agriculturally in the drainage basin therefore fertilizer and pesticide are heavily used. The water authority expects to protect the water quality by determining 3 protection zones but this brings only temporary solutions. Protection of such water mass is only possible by protecting while basin including the rivers.

The models and GIS constructed in this study are detailed and the basin is managed with these systems Mersin and Tarsus will not face a water quality problem for 25-30 years.

MATERIALS AND METHODS

The drainage area and its conditions are determined gram satellite images by using MapInfo. The topographical, geological and hydrological digital maps, settling locations and the waste water discharge points are collected in GIS and the their interactions are estimated. For chemical analysis, a total of 4 samples was taken from Pamukluk and Kadıncık rivulets, Tarsus (Berdan) river and Berdan dam. The fieldwork included water quality measurements (pH, EC, Sal, and temperature). The EC, Sal, T and pH valves measured in the field using pH/cond. 340 i WTW meter. The other pollutants and BOD-DO were measured with Hanna C 200 multiparameter photometer.

The results of these measurements were added the information in the GIS and some thematic maps were produced. The gates of some pollutants were modeled by WQM-Cal (Water Quality Modelling Calculation, Géza Jolánkai and István Bíró, 2000)

GEOLOGY

The chemistry of river waters are directly related to the geological formations. The quantitive and qualitative characteristic of hydraulic systems reflect the geomorphological features of drainage area (Bhutani R & Khanna D R, 2006).

The Pamukluk and Kadıncık rivulets which form the Berdan river, come from the highest altitudes of Tauride mountains. Their velocity is very high and it reaches the delta plain in Tarsus. This speedy flow is good fort he reaeration of the river water. A 3-dimensionel image of the drainage area was constructed by Map Info (Fig.1). This wild geomorphology has a good impact on the dissolved oxygen but it also causes fertilizers and pesticide to be washed from agricultural areas especially during rainy days. These pollutants reach to the rivulets by flood waters.

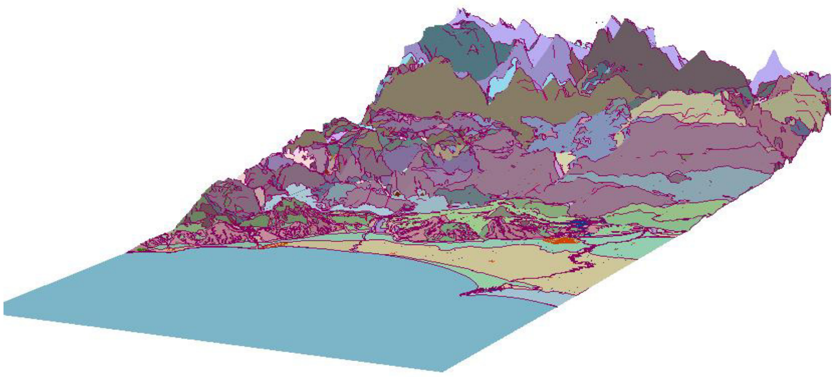

Fig.1: The 3-dimensional image of the drainage area of Berdan river.

The Kadıncık and Pamukluk rivulets flow on the lower-middle Miocene Karaisalı formation and upper miocene pliocene Handere formation. These formations are mostly consisting of carbonate rocks. After parsing the dam, Berdan River flows on the quaternary basin-fill deposit.

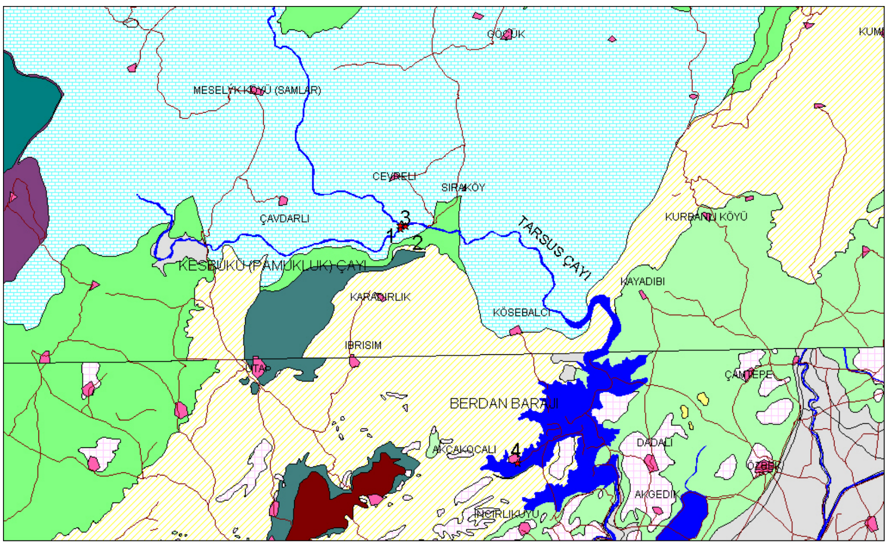

Fig.2 : The regional geologic map and the sample locations.

RESULTS

The water quality parameters were measured at four locations; (1) Pamukluk rivulet, (2) Tarsus rivulet, (3) Kadıncık rivulet and (4) Berdan dam. The sample from these locations were analysed in the laboratory.of Mersin University and the results are showed in Table 1.

Table 1 : The results of analyses.

No	EC (µs/cm)	pH	T (°C)	DO (mg/L)	NO_2-N (mg/L)	NO_3-N (mg/L)	NH_3-N (mg/L)	PO_4–P (mg/L)	SiO_2 (mg/L)
1	310	8.51	12.1	9.8	0	3.0	0	0.05	0.75
2	291	8.32	13.2	8.7	0	3.0	0	0.59	2.20
3	281	8.10	14.6	8.7	0	4.1	0	0.11	2.20
4	281	8.17	16.3	9.8	0	5.4	0	0.03	0.92

Table 1 : The results of analyses.

No	P (mg/L)	I (mg/L)	F (mg/L)	Fe (mg/L)	Cu (µ/L)	Br (mg/L)	Cr (µ/L)	Mo (µ/L)	Mn (µ/L)
1	0.4	0.4	0.26	0	0	0.16	0	0	0
2	0.1	0.1	0.24	0	0	0.99	3	0	0
3	0.5	0.1	0.20	0	0	1.42	0	0	0
4	0.4	0.1	0.28	0.06	0	0.62	0	0	0

The most important factors on the river water quality are the regional geology, land use, topography and the water flow conditions. Due to the dry weather conditions, the nitrate, phosphate and ammonium concentrations in the river water are low (Table 1)

The electrical conductivity (EC) is a good indicator fort he total dissolved solids in water. As shown in Table 1 the EC of Pamukluk rivulet which has a flow rate of 3 m^3/s is 310 µs/cm. The EC of Kadıncık rivulet which has a flow rate of 15 m^3/s is 281 µs/cm. After the mixing of these two rivulets it is measured as 291 µs/cm as expected. This value is under the advised limits.

BOD is also commonly used fort he water quality. The BOD contents of Berdan river and its branches are between 0 and 1 mg/L and this shows that there is not an important organic pollution in the river water. But it must be considered that after rainy days, BOD can increase due to washing of animal wastes. The phosphate concentration is determined as 0.05 -0.59 mg/L in the rivulet water and as 0.03 mg/L in the dam water. The source of this pollutant is organic matters and human animal wastes. The phosphate concentration can also increase after the rainy days.

The heavy metals in the river water are adsorbed by plankton and suspended particular matters or they assimilated by microorganisms. Therefore no heavy metals were determined in Berdan river water.

The dam water only contains iron of 0.06 mg/L

Too many parameters which affect the water quality and the other features such as geology, morphology and land use can only be managed by using GIS. The GIS constructed for Berdan basin contains 18 parameters from 4 (four) sampling points. Since this is an ongoing study, more parameters will be included in the study.

The dissolved oxygen and nitrate are the most important water quality parameters and their pie diagrams are shown in the thematic maps (Fig.3)

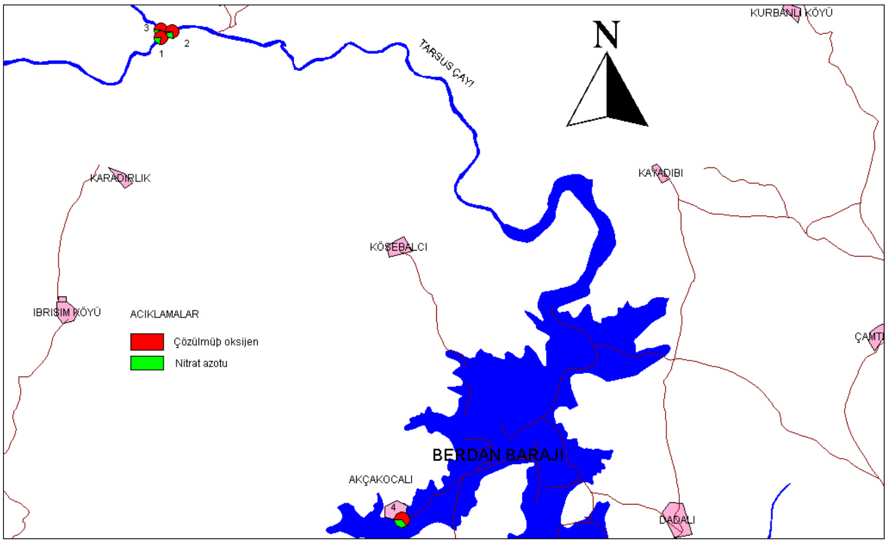

Fig.3 The thematic maps of water quality parameters

Water quality of Berdan River and its branches is modeled by WQM-Cal. WQM-cal contains BOD-DO and the traditional oxygen sag curve. Besides these, WQM can also be used for eutrophication modeling and pollutant input model for lakes.

The BOD values from Kadıncık and Pamukluk rivulets are modeled and the BOD and DO after mixing of them are estimated as 0.91 and 8.8 mg/L, respectively. The results of analyses after mixing points show these values as 11 and 8.7 mg/L. This show that the model is well calibrated (Fig. 4).

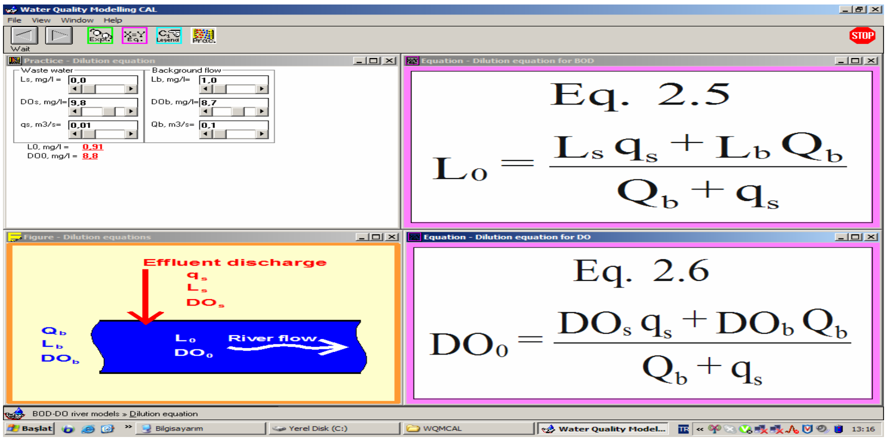

Fig. 4: BOD-DO Model

The WQM-Cal estimates the amount saturated dissolved oxygen as 10.23 mg/L at water temperature 14.6 °C so the oxygen deficit is only 1.4 mg/L (Fig. 5).

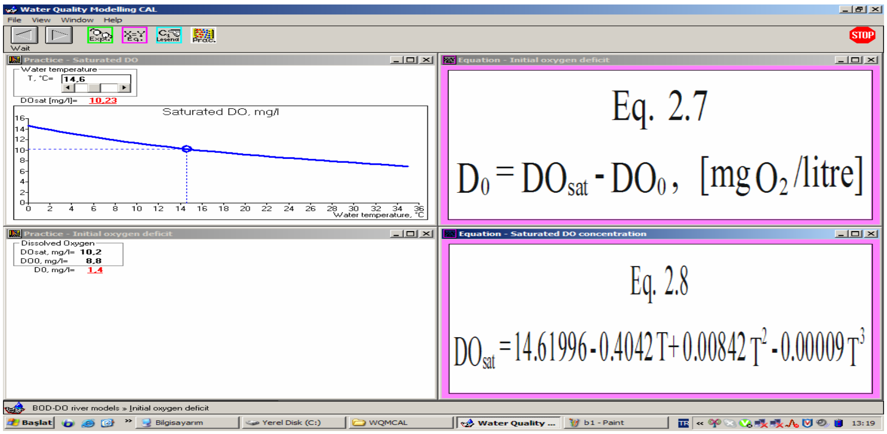

Fig. 5: The determination of oxygen

The reaeration coefficient was estimated as 2.15 1/day by using the flow velocity and river dimensions (Fig. 6).

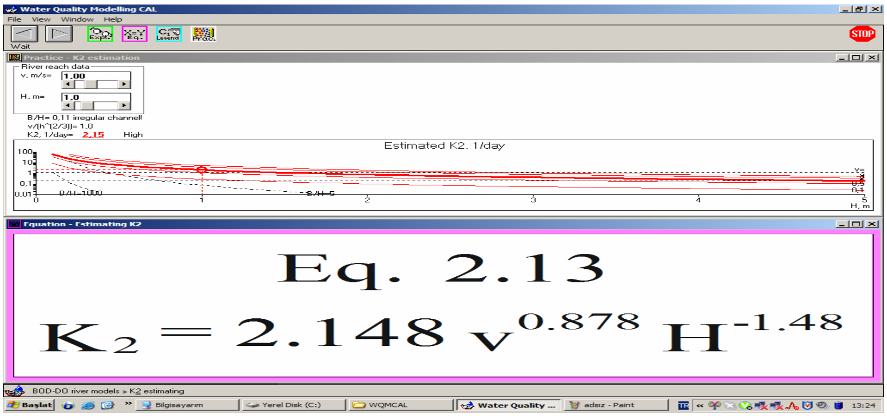

Fig. 6: The determination of reaeration coefficient

WQM determines the decay coefficient by using the reaeration coefficient and this is 1.07 1/day for the Berdan River. WQM also confirms that this is a valid value (Fig. 7).

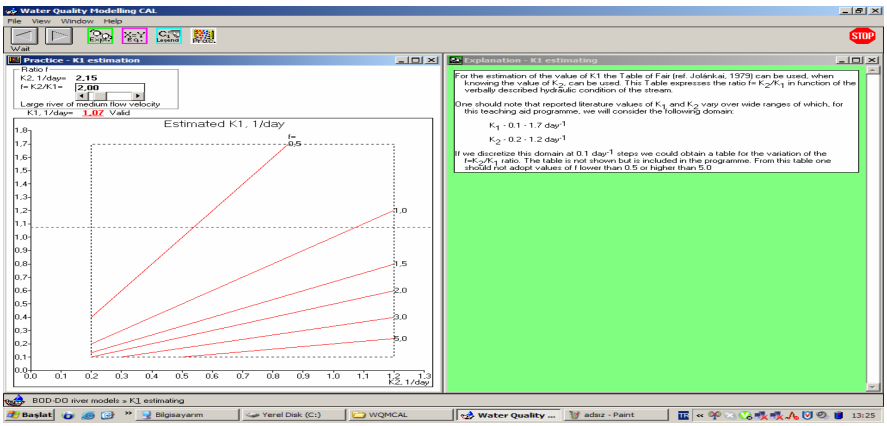

Fig. 7: The calculated of k_1

WQM calibrates the estimated decay coefficient as 0.84 1/day for 14.6 °C water temperature (Fig. 8).

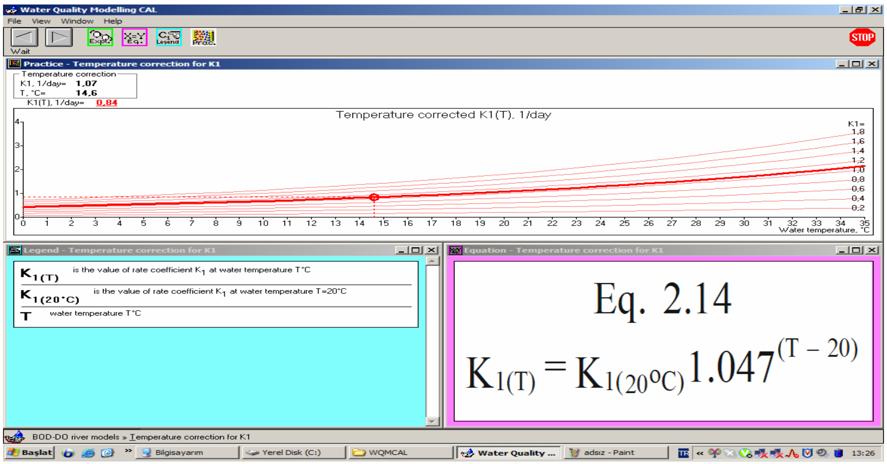

Fig. 8: Correction of decay coefficient for water temperature

The BOD decay model describes the decomposition of biodegradable organic matter in function of the time. The traditional oxygen sag curve model describes the fate, the “sag” of the dissolved oxygen in the river as influenced by the decay of biodegradable organic matter and the reaeration process. The model which was constructed for Berdan River shows that a critical day and critical oxygen content do not occur (Fig. 9).

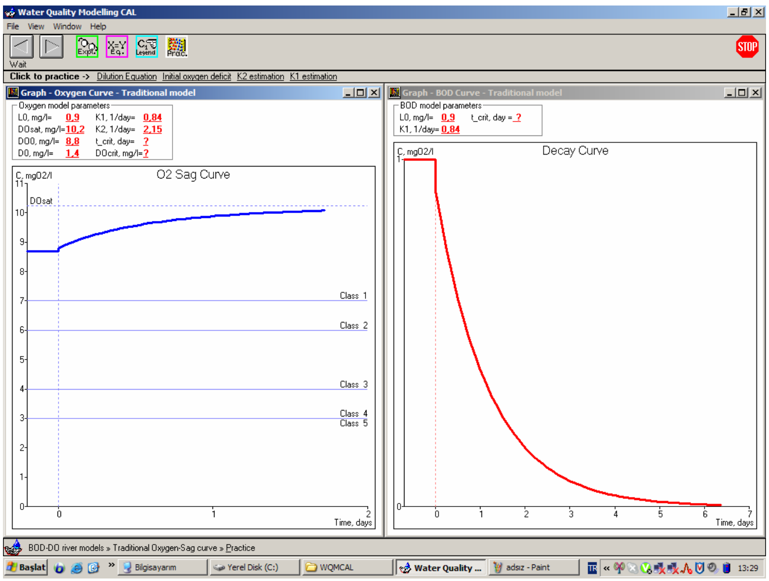

Fig. 9: Oxygen sag curve and BOD model Berdan River

Eutrophication, known as the natural ageing process of standing waters, has dramatically increased since sixties, mostly in industrialized countries, with intensified agriculture, due to the excessive anthropogenic input loads of plant nutrients, phosphorus and nitrogen. Indices of trophic state of a lake are chlorophyll, nitrogen and phosphorus, unfortunately measured chlorophyll contents could not be for Berdan Dam.

Phosphorus is necessary for the growth of freshwater plants, but it is reported that the limit value is 0.02 mg/L (Girija ve et all., 2006). The P content of varies from Berdan river and the dam 0.1 mg/L to 0.5 and these concentrations are to be considered for an alarm for eutrophication.

WQM-Cal includes also an “Input Load Model” (for eutrophication models). In this model input loads of phosphorus are calculated for the eutrophication models. Fig. 10 shows the results of input load model for Berdan Dam.

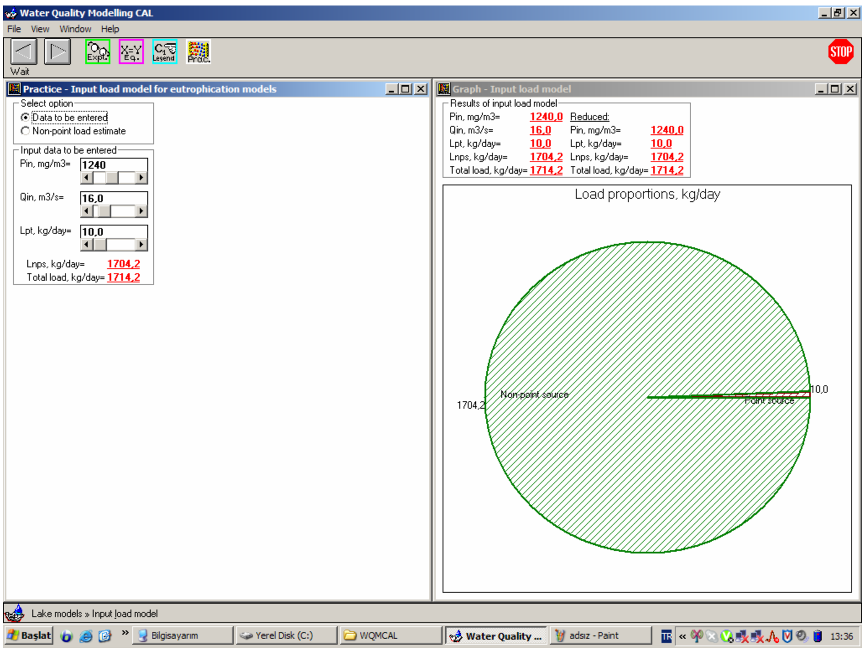

Fig.10: Input load model for Berdan Dam.

WQM model includes also a lake hydrology regulation sub model. The hydrological condition of Berdan Dam was modeled by using estimated hydrological parameters (Fig. 11). This model will be calibrated with detailed parameters in future.

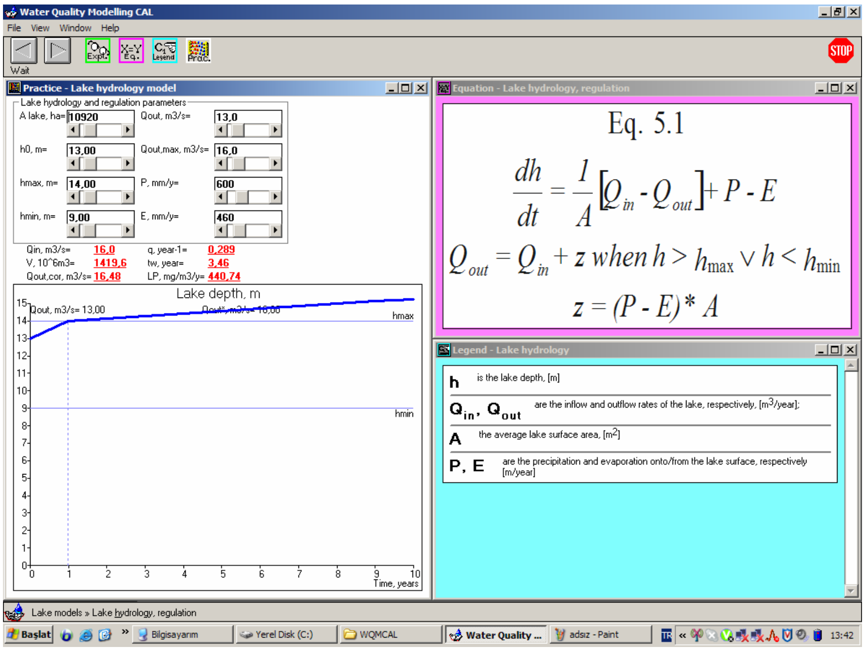

Fig. 11: Hydrological model of Berdan Dam.

CONCLUSIONS

The wild geomorphology of Berdan drainage area has a positive impact on the dissolved oxygen in the river water. The drainage area is intensively used agriculturally; therefore there is a risk of the pollutant input to the river after rainy days.

Due to high flow rate of Berdan River, there is not a negative affect of waste water discharges on the river water quality. The oxygen deficit is determined as 1.4 mg/L, but the model shows that there is not a risk for occurring of the critical day and critical oxygen content in the Berdan River.

Today the GIS is a traditional tool for the management and evaluation of water quality in river basins. The thematic maps constructed for Berdan basin provide the interpretation of many parameters.

The eutrophication state was modeled by using WQM input load sub model. In the future, the chlorophyll content of dam water will be determined and an eutrophication model will be run.

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