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Application of an Artificial Intelligence to the Estimation of Water Quality Parameters: Water Quality of Nigde Creek Water, Turkey

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Artificial intelligence is used for the estimation of water quality parameters of Nigde creek in the central part of Turkey. Nigde creek basin contains the two largest region of Turkey which is Nigde city and Bor district. Moreover, it is the major agricultural area in the region as well as highly agricultural and industrialized. In this study, analyses have been conducted on water samples taken from five stations located along the Nigde creek. Hydro-chemical analyses have been conducted on the water samples, the results have been evaluated according to water quality parameters. The laboratory data with an artificial neural network computer program called clean water quality program-CWQP, which is designed according to water quality parameters, its place has been defined among the classifications of water quality. Quality parameters used have been prepared in compliance to the In-continent surface water classification as stated in the regulation of water pollution and checking for Turkey. Accordingly, water quality has been classified in four groups as Quality I, II, III and IV. Selection of appropriate input parameters to estimate another one is key to use ANN. This is essential to obtain maximum success with minimum error. The input parameters selected must be those which affect most the output one. In this study, therefore, water quality at five stations has been determined to be of Class IV water quality with CWQP. Furthermore, lead has stepped up as the most important polluter in the analyses, which has the negative effects on water quality in all stations and precautions are needed to be taken to protect Nigde creek. Results obtained from the CWQP have been discovered to be indifferent from the ones obtained through the classical methods, implying their availability for use comfortably in water pollution areas. This program has ensured rapid results and non-specialized study in determining the water quality.

Key Words: Water quality, Heavy metals, Artificial intelligence, Water pollution, Nigde, Turkey.

INTRODUCTION

Quality of water, which plays a key role in the cycle of nature, is of

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great importance. Fresh waters like rivers, creeks, lakes and underground waters comprise a small amount in general among the existing waters. Today, most of the resources used for drinking and general use are supplied from rivers and creeks. Therefore, rivers and creeks are of high importance. Generally, the volume of water mass in rivers[1] is annually 37,000 km^3. Potential of surface and underground water resources in Turkey is approximately 200 km^3. However, total utilizable annual potential in Turkey is approximately 104.5 km^3. Actively used annual water amount in Turkey is between 40-50% of the total water potential[2].

Though less in amount, rivers serve for many fields of use. These waters are used for drinking, general purpose, agriculture, industrial activities and in many more fields. In the past, water pollutions were primarily caused by microbiological elements. According to Lippy and Waltrip[3], 52% of water related diseases in USA between 1946 and 1980 were caused by unknown reasons, 22% by bacteria, 12% by viruses, 7% by parasites, 4% by inorganic chemical substances and 3% by organic chemical substances. In same years, 8% of epidemic diseases related to drinking water systems were caused by unpurified and polluted surface waters[3]. 38% of diseases between 1989 and 1990 were caused by surface waters[4]. Thus, interpretation of hydro-chemical analysis results in waters and determination of water quality have become important. Along with the effects of environmental factors, variation in water quality of rivers becomes unavoidable. Due to excess usage of water in rivers, a rapid and safe determination of water quality is required. Development of water quality standards against all these negative developments has become a must. In this scope, scientists have developed the "water quality criteria" to regulate water quality standards[5].

Recently, alternative methods of data analysis, like neural network, fuzzy logic and artificial intelligence based algorithms have emerged as interesting tools for time series analysis[6-10]. The current techniques for numerical simulation of water quality are highly specialized tasks requiring detailed knowledge. Up to now, a variety of water quality models are available and the techniques become quite mature[11]. Due to the complexity of numerical of water quality in environmental studies[12,13], there is an increasing demand to integrate artificial intelligence (AI) with these new programs.

The objective of the present study is to integrate descriptive knowledge, procedural knowledge and reasoning knowledge for a knowledge management system on water quality modeling together with AI technology[11]. Benefiting from the computer program has become a requirement to develop reception of safe and rapid results in determination of water quality. Computer studies with artificial intelligence (AI), taking "water

quality criteria" and pollution variation in creeks into consideration can be seen as the beginning of an extensive study.

Determining the water quality of samples, taken from sample stations on Nigde creek which runs down along Nigde city center, is considered to form an example for our study. The purpose here is to determine the water quality of Nigde creek in a faster and safer way by using an artificial intelligence (AI) application called "CWQP-clean water quality program". Furthermore, other scientists will be able to use the application of the artificial intelligence which is the CWQP for various purposes. Rapid and safe determination of water quality with this program will ensure a large field of application for the productive utilization of surface waters and discovering the effect of resources on environmental and ecological balance. For this reason, evaluation of many analyses in the shortest time possible by less-specialized staff is of great significance in water quality determination works to be conducted with the artificial intelligence (AI).

EXPERIMENTAL

Nigde creek roots from the northeast of Nigde and ends in the Akkaya Dam in the southeast. Most of the city industrial waste is connected to the creek. Thus, attention has been shown for the stations from which samples were taken to represent Nigde creek in general. In addition, five stations have been designated considering the effects of pollution areas which can be created by the resources spread along the creek, residences and agricultural fields.

Station 1: This place has been chosen considering it to be less polluted and suitable to research effects of the industrial and city sewerage systems and to monitor the change of these effects on CWQP. **Station 2:** there are residences around this station 1100 meters away from the first one. Furthermore, it is located next to the city stadium, at the beginning of industrial zone. Having a nearby industrial zone will show the effect of industry on creek. **Station 3:** this station exists at the industrial site exit and partially surrounded by residences. It is chosen to research the effect of slaughterhouse at front and partially the agricultural fields on the creek. **Station 4:** It is an area close to the slaughterhouse but away from urbanization with partial agricultural activities. **Station 5:** this is an important spot for being located at the end of slaughterhouse and refinery area where refinement water flows into the creek and surrounded partially by agricultural fields. After this station, no pollution resource has been thought to exist, excluding the agricultural fields, to effect possible pollution of dam water (Fig. 1).

A standard method was used for sampling[14]. Water was collected in polyethylene bottle 0.5 m below the surface at five sample station along

the creek stream. All glass and plastic ware used for sampling and analyses were rinsed with milli-Q water. Filtration was made through glass-fibre filters. All measurements were performed the day as samples were gathered.

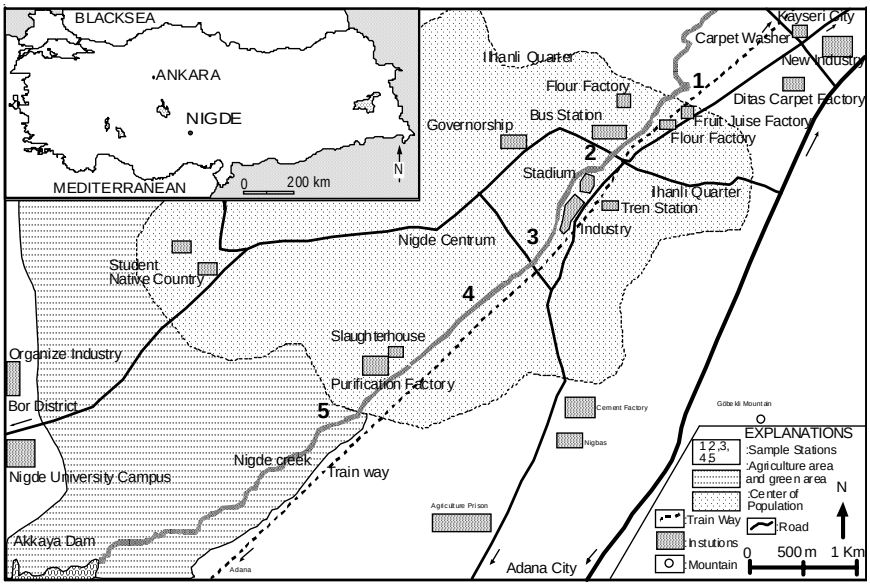

Fig. 1. Study area and samples stations

Instruments and reagents: Field surveys have been conducted using WTW-LT 330 portable "conductivity meter" (SCT), Orion "pH meter" and YSI_055 "oxygen meter". In analyses, measurements have been made with Cadas 50 S UV Spectrometer. Measurement ranges have been set between 190-1100 nms by using Mercy ready kit in the equipment. It has a 2 nms wide monochromatic and quartz plated optics with a photometric ratio of 0.3 A.

Spectrometric determinations: Data to be used in the computer program applied are the results of hydro-chemical analyses of water samples taken from the subject creek. Therefore, water samples have been taken from five stations along the Nigde creek which runs through city center and feeds the Akkaya dam lake. In accordance with the standards given in *regulation of water pollution and checking*, attention has been shown for water samples taken not to be less than 1 L. 1 L water samples were required for the analyses. Samples taken have been sent to the laboratory in the same day for disinfection. Hydro-chemical analyses of water samples have been conducted for copper, zinc, cyanide, iron, nickel, lead, cadmium and fluorite by Adana provincial directorate of environment laboratory. Place of samples among water classifications has been determined by

applying the obtained hydro-chemical results to the CWQP which is designed according to the water quality parameters.

For hydro-chemical analyses, samples have been taken from the stations in plastic bottles in compliance with the standards. Following the numeration of the samples taken, well-head experiments have been performed at each station. These experiments are heat, pH and dissolved oxygen values. Results have been put in the related station's chart. For each station, these actions have been repeated. Following the completion of taking samples and surveys, samples have been sent to the laboratory in the same day. Hydro-chemical (physical-chemical) variations of water samples from 5 stations covering the examination field have been measured in the laboratory. After hydro-chemical analyses are conducted for each station, determined values are evaluated along with heat, pH and solved oxygen. Water quality have been determined by considering both field and laboratory data.

To determine the water quality, certain classification and parameters should be used. Quality parameters used in this study have been chosen in compliance to the In-continent surface water classification given in the *regulation of water pollution and checking*. The classification of fresh water resources like rivers, lakes and dams are made into four groups. However, quality parameters are gathered into four groups as physical-chemical, organic, inorganic pollution and biological parameters[15]. This classification is as follows: **class I:** high quality water, **class II:** less-polluted water, **class III:** polluted water and **class IV:** very polluted water[15].

Installation of artificial intelligence algorithm (CWQP-clean water quality program)

Artificial Intelligence is defined as understanding the structure of human thinking and the effort to develop computer operations able to display actions similar to human. In a more extensive expression, it is the thinking attempt of a computer programmed for and capable of actions unique to human mind like information reception, perception, vision and thinking and decision-making. In brief, it is the attempt of a computer to think. In essence, human being uses and processes the knowledge. Thus, knowledge and its utilization are key characteristics of artificial intelligence[16].

Using the knowledge utilization feature of artificial intelligence, it has been tried to group hydro-chemical analyses of samples taken from stations. In this scope, a software (CWQP-clean water quality program) has been developed in MSDN visual.net programming language to determine the water quality, previously determined with the classical method, using a computer program. Program has been tested on a computer with P4

processor and 256 mb memory. Net framework 1.1 should be installed for the program to work. Criteria to be accepted as entry signals to the artificial intelligence application have been determined as the result of analyses conducted at five prescribed stations in the field. Part of these criteria has been met in the field and part of them in the laboratory. In determination of water quality, program, capable of decision-making on the analysis result given to system, leads to result according to criteria appropriate to water's field of use (Fig. 2).

PARAMETER	Classification of Water Quality			
Class	I	II	III	IV
Temperature	25	225	30	>30
pH	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0
Copper	0.02	0.05	0.2	>0.2
Zinc	0.2	0.5	2	>2
Cyanide	0.01	0.05	0.1	>0.1
Iron	0.3	1	5	>5
Nickel	0.02	0.05	0.2	>0.2
Lead	0.01	0.02	0.05	>0.05
Cadmium	0.003	0.005	0.01	>0.01
Fluoride	1	1.5	2	2

APPLICATION FOR ARTIFICIAL NETWORK	
Enter Temperature	0
Enter pH	0
Enter Copper	0
Enter Zinc	0
Enter Cyanide	0
Enter Iron	0
Enter Nickel	0
Enter Lead	0
Enter Cadmium	0
Enter Fluoride	0

Fig. 2. Application model for clean water quality program

RESULTS AND DISCUSSION

Determination of water quality with the classical method

Table-1 shows the results of hydro-chemical analysis dated November 2003 and water quality limits used in the classical method and computer program to determine the water quality in Nigde creek. Number of parameters in Table-1 can easily be compared with other works.

Physical quality parameters obtained as the result of analyses conducted on samples taken from total five stations beginning from November 2003, have been graphically evaluated with their heat, pH and solved oxygen values (Fig. 3).

According to these measurements, station 2 has the lowest and station 3 the highest heat value. Heat measurements have been performed at evening hours and heat values vary between 8-10ºC. pH value varies between 6.8-7.8 where **station 1** has the lowest and **station 3** and **4** the highest value. pH variation have not shown much difference in measurements. However,

it is possible to say that creek water has slight basic character. In the study, no waste water discharge and similar effects to cause pH value's oscillation have been detected. Chemical quality parameters, nitrite and nitrate and all concentrations at stations have been evaluated together with heat and dissolved oxygen (Fig. 4).

TABLE-1
WATER QUALITY CRITERIA

Parameter	Classification of water quality[16]				Sample Stations				
	Classes				Stations				
	I	II	III	IV	1	2	3	4	5
Temp. (ºC)	25	25	30	>30	8.2	8	10	9.3	8.3
PH (mg/L)	6.5-8.5	6.5-8.5	6.0-9.0	6.0-9.0	6.8	7.5	7.8	7.8	7.4
Copper (mg/L)	0.02	0.05	0.2	>0.2	0.102	0.150	0.043	0.019	0.033
Zinc (mg/L)	0.2	0.5	2	>2	0.1	0.138	0.217	0.19	0.068
Cyanide (mg/L)	0.01	0.05	0.1	>0.1	0.003	0.001	0.110	0.120	0.102
Iron (mg/L)	0.3	1	5	>5	0.048	0.114	0.124	0.085	0.147
Nickel (mg/L)	0.02	0.05	0.2	>0.2	0.080	0.140	0.370	0.101	0.198
Lead (mg/L)	0.01	0.02	0.05	>0.05	0.120	0.125	0.060	0.100	0.125
Cadmium (mg/L)	0.003	0.005	0.01	>0.01	0.01	0.01	0.01	0.01	0.01
Fluoride (mg/L)	1	1.5	2	2	0.420	0.230	0.121	0.260	0.320

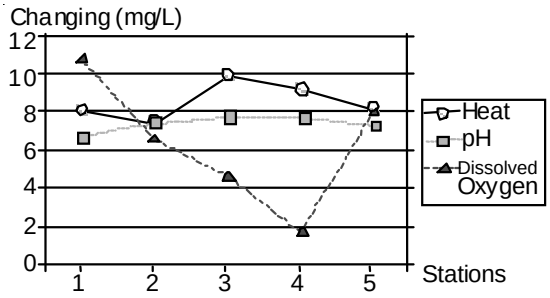

Fig. 3. Physical quality parameters (November 2003)

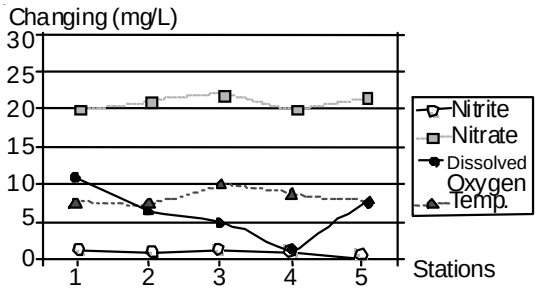

Fig. 4. Chemical quality parameters, nitrite and nitrate (November 2003)

As a result of analyses, nitrate value has been completely < 22. Reason for that is considered to be the agricultural fields not being in the fertilization and disinfection period. Source of nitrate in soil can be considered as

the fertilizers and mineralization of organic matters in the soil. Nitrite concentration has been measured as < 2 at all stations. Nitrite source is mostly created by nitrification of ammonium and ammonia in water and nitrate's reducing reactions in its denitrification. Under aerobic conditions, nitrification occurs in water mass and denitrification in base mud. Nitrite is increased to nitrate or reduced to ammonia and ammonium which shows its dependency in these to parameters to exist[1]. As the result of metal group quality parameter analyses, copper and iron concentrations, obtained from the variation of metal ion solutions in water depending on its heat and pH value, have been evaluated together with heat and pH values of all stations (Fig. 5).

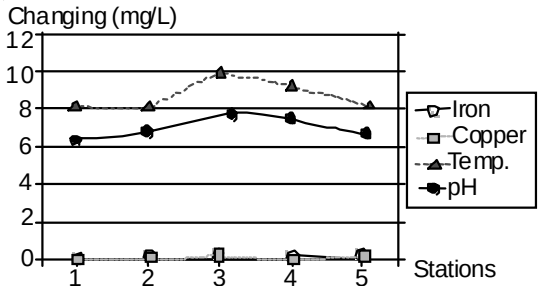

Fig. 5. Metal group quality parameter on its heat and pH value

Determination of water quality with CWQP

A program (CWQP) has been developed referring to the standards given in the *regulation of water pollution and checking*. This computer program has been created referring to the quality parameters used in the In-continent surface water classification given in the *regulation of water pollution and checking*.

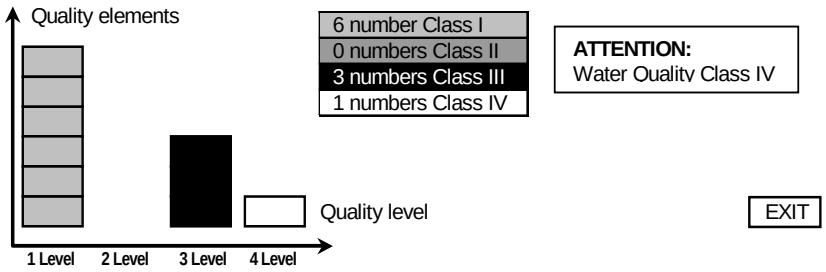

Fig. 6. Hydro-chemical analyses in November, 2003

It has been shown attention in the program that, in determination of water quality classes, all quality parameters must meet their determined quality classes[17]. However, all parameters excluding copper, lead and cadmium, normally measured values at **station 1** show a first class water

quality. Copper and cadmium concentrations fit for **class III** and lead concentration fit for **class IV**. Nevertheless, analysis results according to the computer program show water quality at **stations 1-5** to be of **class IV**. Briefly, in parallel to our goal, according to hydro-chemical analyses conducted in November, 2003, CWQP water quality has been determined to be of **class VI**. The results have been compared to the results of classical method. CWQP, a computer program designed for determination of water quality, has proved to be in harmony with the classical method and ended successfully. CWQP has proved its applicability to this study (Fig. 6).

Conclusion

Though they look clean in samples, creeks which have a wide field of use in daily life may be polluted according to the hydro-chemical analyses. For this reason, it is required for all potential creeks to go under hydro-chemical analyses and their water qualities to be determined with the classical methods or computer programs (artificial intelligence). It has been observed that CWQP application can be used similar to classical methods in determination of water quality. Using CWQP, which is capable of making an expert's analysis interpretation, it will be possible to track numerous samples faster. Hence, easiness in determination of pollution in creeks will lead application fields to expand.

According to these analyses conducted in fields of stations on Nigde creek, **station 2** has the lowest and **station 3** the highest heat value, varying between 8-10ºC. pH value varies between 6.8-7.8 where **station 1** has the lowest and **station 3** and **4** the highest values. It is possible to say that Nigde creek is of light basic character. Nitrate value is < 22 at all stations. The reason for low value can be given to that November (2003) is not the fertilization and disinfection period of the agricultural fields. Nitrite concentration has been measured as < 2 at all stations. According to hydro-chemical analysis results of stations on Nigde creek, high lead anomaly shows water quality to be in **class VI** (much polluted water). It has been observed that when lead, the main polluter in water, is not taken into consideration, water quality shows positive changes. Thus, lead as the main pollutant should be immediately prevented to mix into Nigde creek.

As the result of hydro-chemical analyses on water samples taken from 5 stations in November (2003) and field surveys of stations, water quality has been determined to be in **class VI** (much polluted water) with classical methods in Nigde creek which is important for feeding the Akkaya Dam lake. Water quality has also been determined to be in **class VI** (much polluted water) with CWQP which is an artificial intelligence application.

REFERENCES

1. O. Uslu and A. Türkman, Su Kirliligi ve Kontrolü, T.C Basbakanlik Çevre Genel Müd. Yayinlari, Egitim Dizisi 1, 360, Ankara, Turkey (1987) (in Turkish).
2. H. Elhatip, N. Gülbahar, and Y. Kurmaç, Türkiye'de Çevre, Insan ve Su kaynaklari, Türkiye Su Kongresi, 8-10 Ocak, ITÜ, Istanbul, Turkey (2001) (in Turkish).
3. E.C. Lippy and S.C. Waltrip, *J. Am. Water Works Assoc.*, **76**, 60 (1984).
4. B.L. Herwaldt, G.F. Crawn, S.L. Stokes and D.D. Juranck, *J. Am. Water Works Assoc.*, **84**, 129 (1992).
5. EPA, US Environmental Protection Agency, Quality Criteria for Water, Washington, D.C. (1976)
6. T.A. Clair and J.M. Ehrman, *Water Resour. Res.*, **34**, 447 (1998).
7. G. Nunnari, A.F.M. Nucifora and C. Randieri, *Ecol. Model.*, **111**, 187 (1998).
8. H.R. Maier and G.C. Dandy, *Water Resour. Res.*, **32**, 1013 (1996).
9. H.R. Maier and G.C. Dandy, *Environ. Model. Softw.*, **15**, 101 (2000).
10. C.W. Dawson and R.L. Wilby, *Hydrol. Earth Syst. Sci.*, **3**, 529 (1999).
11. K.W. Chau, C. Chuntian and C.W. Li, *Expert Syst. Appl.*, **22**, 321 (2002).
12. K.W. Chau and H.S. Jin, *J. Environ. Eng.*, **124**, 628 (1998).
13. K.W. Chau and X.Z. Zhang, *Adv. Eng. Softw.*, **22**, 139 (1995).
14. Water Quality-Sampling, Part II: Guidance on Sampling of Ground Waters, ISO 5667-11 (1992) (in Turkish).
15. SKKY (Su Kalite Kontrolü Yönetmeligi), 4.9.1988 Tarih ve 1991 Sayili Resmi Gazete, 93-98s, Ankara, Turkey (in Turkish).
16. T. Dereli, Toplam kalite yönetiminin isigi altinda yapay zekanin endüstriyel problemlerin çözümünde kullanimi (seminer), Mühendislik Fakültesi, Endüstri Mühendisligi (2000) (in Turkish).
17. A. Bayram, Y. Orhan, H.B. Özkoç and H. Büyükgüngör, Kizilirmak Deltasi yüzey suyu kirlilik arastirmasi, Türkiye'de Çevre Kirlenmesi Öncelikleri Sempozyumu II, Gebze/Turkey (1997) (in Turkish).

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