Environmental Monitoring and Assessment (2006) **116:** 543–562
DOI: 10.1007/s10661-006-7671-9

SIMULATION AND TREND ANALYSIS OF THE WATER QUALITY MONITORING DAILY DATA IN NESTOS RIVER DELTA. CONTRIBUTION TO THE SUSTAINABLE MANAGEMENT AND RESULTS FOR THE YEARS 2000–2002

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(Received 24 January 2005; accepted 19 May 2005)

Abstract. The transboundary River Nestos in the Balkan Peninsula is a surface water resource shared by Hellas and Bulgaria. The *Public Power Corporation of Hellas* (*DEH*) proceeded to the dams' construction of Thesaurus in 1997 and Platanovrissi in 2000, to satisfy the increased needs for power production and irrigation in the Regions of Eastern Macedonia and Thrace in the Hellenic Territory. DEH following the Ministerial Agreement of the Hellenic Parliament "KYA 18492/19–09–1996" funded a series of Research Projects concerned on the monitoring of the water quantity and quality data of Nestos from the Hellenic-Bulgarian borders to its estuaries in the Thracian sea. "PERSEAS" Research Group from Aristotle University of Thessaloniki, carried out the research, design, construction, installation, operation and maintenance of the "R.E.MO.S." (Remote Environmental MOnitoring System) networks. Three REMOS networks have been installed in the areas of (a) the River Nestos deltaic channel, (b) Thesaurus dam-lake in the intramountainous valley and (c) Potamoi (Despat) and Pagoneri (Nestos) villages close to the borders between Hellas and Bulgaria. They record water level (H), water and air temperature (T), water conductivity (ECw), Redox potential (RP) and dissolved oxygen (DO) on a 24 h basis, since the beginning of the year 2000. The research carried out in this paper, is focused on the REMOS station in the final course of Nestos in the deltaic area. The continuous monitoring and the data analysis yield useful results for the quality and quantity of the hydrologic regime of Nestos after the dams' construction, as well as for the trends detected of the quality parameters (ECw, RP and DO) and the water level, using the nonparametric Spearman's criterion. The best fitted model of time trend, for each variable, was chosen. The statistical sample of each one of the quality variables consisted of about 1000 values based on daily measures on a three years monitoring program (1/1/2000–31/12/2002). Further research and analysis for the other network stations of REMOS should provide useful results for the sustainable management of the transboundary River Nestos.

Keywords: Hellas, transboundary river nestos, monitoring, water quality, PERSEAS, R.E.MO.S., sustainable management, trend analysis

1. Introduction

In the present study, research is carried out concerned on the daily average water quality data recorded in the Nestos deltaic channel for a three-year period and the trend analysis of these monitoring data. The research is focused on the three points below:

- The necessity of continuous monitoring of the hydrological regime and the quality parameters of the surface transboundary water resource of Nestos River in its delta. This necessity has prevailed after the construction and operation of the hydroelectric dams of the DEH (dam-Lakes of Thesaurus and Platanovrissi), in the Hellenic part of Nestos Basin. The "KYA 18492/19–09–1996", imposed measures for the continuous monitoring, the control of the quality parameters in Nestos River and the ecological preservation of the natural environment. DEH financed the research which was carried out by the Aristotle University of Thessaloniki in a series of Research Projects and scientific papers (Psilovikos *et al.*, 1999, 2002, 2004; Psilovikos *et al.*, 2005; Albanakis *et al.*, 2001; Moustaka–Gouni *et al.*, 2000).
- The design, construction, installation, operation and maintenance of integrated telemetric networks of electronic stations by PERSEAS team. These networks of stations record in a daily basis, successively for three years quantitative and qualitative parameters of the hydrologic regime of Nestos River from the Hellenic-Bulgarian borders to its deltaic mouth. The study is focused on the station installed first in the deltaic channel of River Nestos, close to the Town of Chrysoupolis. This station operated for three years and the daily records have created dense time series.
- The development of the hydrologic and water quality information of the time series. These time series have prevailed on a record program as average daily values of monitored parameters every two hours. The development of the hydrologic information took place with the Spearman's criterion for the existence of trends and the statistical test using the Student distribution. The results of the trends for the years 2000–2002 are obtained, for the quantitative and the qualitative hydrological regime in Nestos Delta. Moreover a comparison was made between the hydrological regimes of the river before and after the dam construction. The obtained results indicate that the river flow is approaching a state of normalization.

2. Natural Environment Data

The River Nestos is considered as one of the most important transboundary surface water resources in the Balkan Peninsula extended over a hydrological basin of 5414 km^2. The annual river flow ranges between 1.0–1.5 $\times 10^9$ m^3/yr while the total sediment transport is estimated 0.5–1.0 $\times 10^6$ m^3/yr (Psilovikos *et al.*, 1999) before the construction of the dams in the Hellenic territory. The river basin is shared by the two neighbouring countries of Hellas and Bulgaria (Figure 1). Nestos occupies an intramountain basin of the western part of the Rhodope (Choleev and Baltakov, 1989; Psilovikos *et al.*, 1988). It drains 3317 km^2 (61.27% of the total basin) of

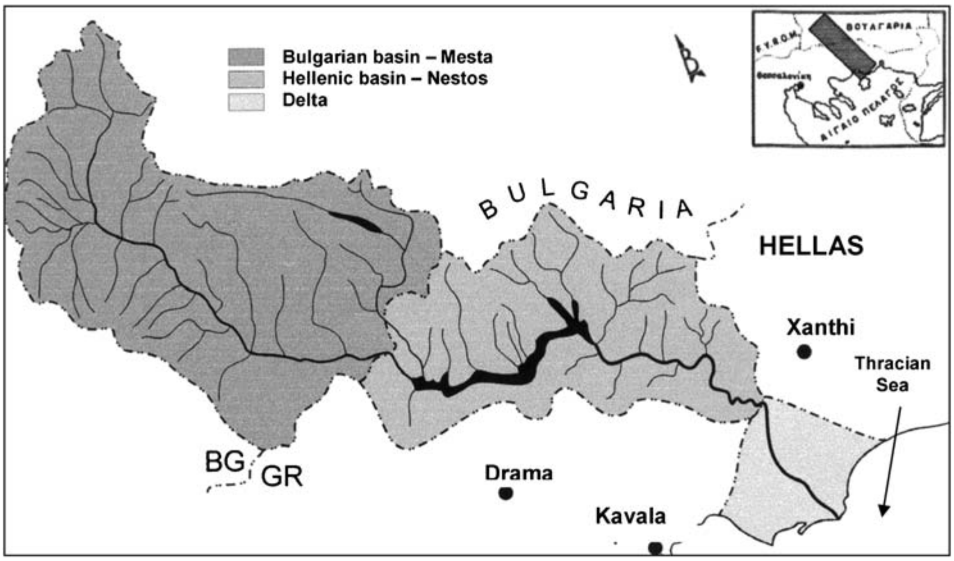

Figure 1. The Nestos transboundary hydrological basin shared by Bulgaria and Hellas.

the Bulgarian territory as Mesta (North) and 2097 km^2 (38.73% of the total basin) of the Hellenic territory as Nestos (South). At the coastal zone of rivers discharge in the North Aegean Sea, Nestos forms an extensive deltaic plain of 615 km^2 area. It is included in the Ramsar Convention as an internationally important wetland complex (Gerakis and Kalburtji, 1998; Zalidis and Mantzavelas, 1996).

Human impact of the natural deltaic plain was considerable in the last half of the 20th century (Psilovikos *et al.*, 1999). Almost 88.45% of natural wetlands turned into irrigated land, leaving the rest as a natural deltaic area. The river was incised into a large – wide artificial channel in the middle of the deltaic platform (28 km^2 in area), to protect the fertile irrigated land from flooding. The coastal zone still remains a natural area with coastal lagoons, seasonal marshes and sandy beaches (43 km^2 in area). In spite of these considerable anthropogenic changes in the deltaic system, the river flow retained its natural characteristics, all through the 240 km river course.

In the last decade of the 20th century, DEH constructed the multipurpose dams of Thesaurus and Platanovrysi in the mountainous river basin in the Hellenic territory. Their characteristics are given below:

- Thesaurus : Highest Operational Level +380 m above sea level, lake area 18 km^2, lake volume 705×10^6 m^3 and
- Platanovrysi: Highest Operational Level +227.5 m above sea level, lake area 3 km^2, lake volume 73×10^6 m^3.

On the Bulgarian drainage basin of Mesta the dam of Despat constructed and operated well before the dams of the Hellenic side (Stoichev, 1989). All the dams provide hydroelectric power, water for irrigation and antiflooding protection of the basin lowlands and the deltaic plain. The construction and operation of dams within the mountainous zone of Nestos, have certainly changed several characteristics of the flow regime of the river. It also brought several changes in the environment of the deltaic platform, as well as in the life of local farmers and the economy of the broader area. Some of them have positive effects on the population. Some others need further study to clarify their effects upon the environment.

As a shared river between Bulgaria and Hellas, Nestos have affected the relations of both countries that reached a bilateral agreement in 1995. The agreement set up the framework of both countries for the river management. This requires also monitoring of the river, exchange of information and common decisions. Nestos River is also important to international society for its deltaic system and the associated defile, known as "Stena Nestos". They are both protected by the Ramsar Convention, by the Directive 409/79/EC, by the Bern Agreement and several other legal acts of international importance.

3. Materials and Methods

3.1. The monitoring network "REMOS" in river Nestos

PERSEAS research group of the Aristotle University of Thessaloniki, constructed, installed, operated and maintained for DEH three monitoring networks of REMOS to provide data for water and environmental management (Psilovikos *et al.*, 2002). For three years (beginning of 2000–end of 2002) the remote automated REMOS, monitored qualitative and quantitative parameters of Nestos River on a daily basis, such as water conductivity (ECw – μS/cm), dissolved oxygen (DO – mg/L), redox potential (RP – mV), water temperature (Tw – $^\circ$C), air temperature (Ta – $^\circ$C) and water level (H – cm), providing very dense time series. These records provide information about the trends of quality and quantity parameters. Moreover they are the first step to create an electronic data base for the modelling and management of Nestos. The REMOS network has the following characteristics (Psilovikos *et al.*, 2002, 2005):

- It is an electronic system for automated measurements of water and air parameters.
- It forms a network of remote telemetric stations, which continuously monitors electronically the values of various parameters in environmentally sensitive ecosystems.
- It has advanced capabilities, which is implementing the approach of "Integrated Environmental Monitoring" that is the integration of many different kinds of environmental measurements to a common computerized structure.

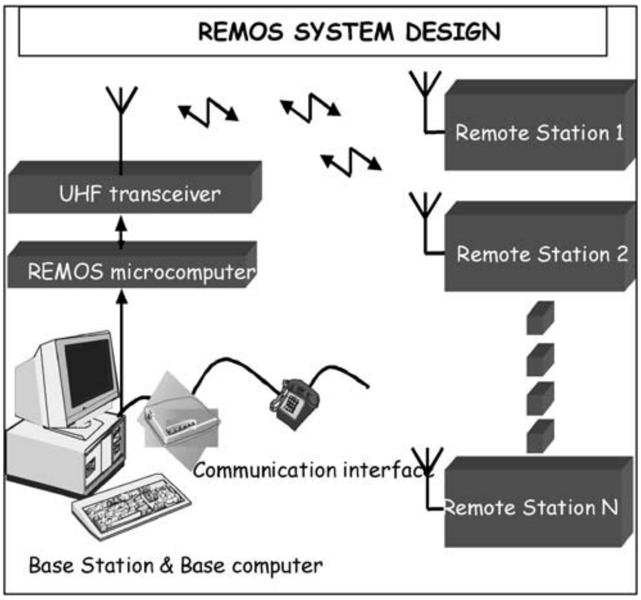

Figure 2. REMOS system design.

- It can support a decision tool in cases of extreme values phenomena and prevent from natural hazards and disasters.

Each one of the networks of REMOS consists of

- A *Base Station* (*B.S.*), equipped with a base computer, a communication interface, a UHF transceiver to communicate (Figure 2) and
- Two or more *Remote Stations* (*R.S.*) (Figure 3), equipped with a microcontroller unit, a communication interface, a UHF transceiver, a solar panel, a battery and several measuring units (sensors). The number of the monitored parameters is a maximum of 16.

The Nestos monitoring network consists of three network stations (Figure 4) which are:

- The *Lower – Southern – network* at Nestos deltaic plain. This network operates at the deltaic platform, with three stations. It is the oldest network and it operates since the beginning of the year 2000.
- The *Middle – Central – network* of Thesaurus dam area. This network has been installed in the intramountainous valley of Nestos, particularly in the dam – Lake of Thesaurus and operates since 2001.
- The *Upper – Northern – network* of Potami–Pagoneri area close to the Bulgarian borders. This is the most recent network and has been installed at the rivers

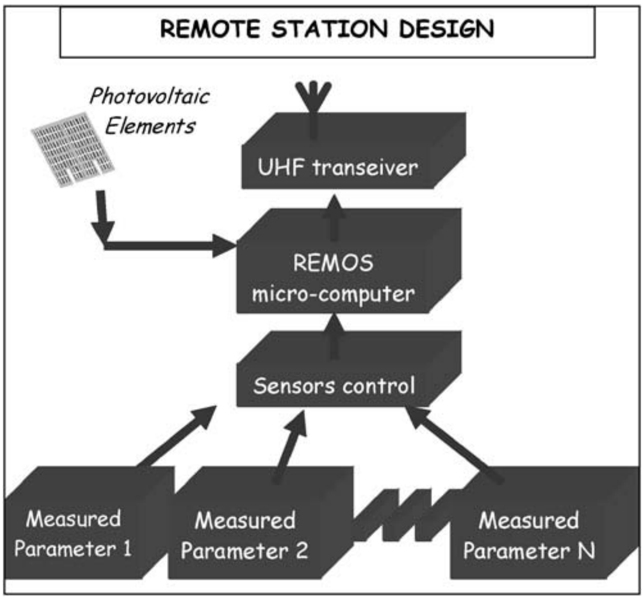

Figure 3. Remote station design.

Despat (Potami Village) and Nestos (Pagoneri Village) close to the Bulgarian – Hellenic borders.

So Nestos river flow is monitored in its entire basin of the Hellenic part, from the borders to the Thracian Sea. The *Lower – Southern – network* on the deltaic plain of Nestos, consists of a Base Station (B.S.) in Keramoti harbour and two Remote Stations (R.S.). The first one is in the Nestos channel close to Chrysoupoli Town and monitors the river flow and the water quality. The second one is in the Agiasma lagoon on the western deltaic trend to monitor water changes as well as certain qualitative parameters of the lagoonal water. The study is focused on the monitoring and analysis of the first *R.S.* at Chrysoupoli called "*Nestos*". Water level, water and air temperature, conductivity, redox potential and dissolved oxygen, considered important parameters that measured continually 24 h per day for three full years in Nestos delta.

3.2. Trend analysis model of the monitored data

Testing water quality data for trends over a period of time has received considerable attention recently. The interest in methods arises for two reasons (Antonopoulos *et al*., 2001):

- The intrinsic interest in the question of changing water quality arising out of the environmental concern and activity.

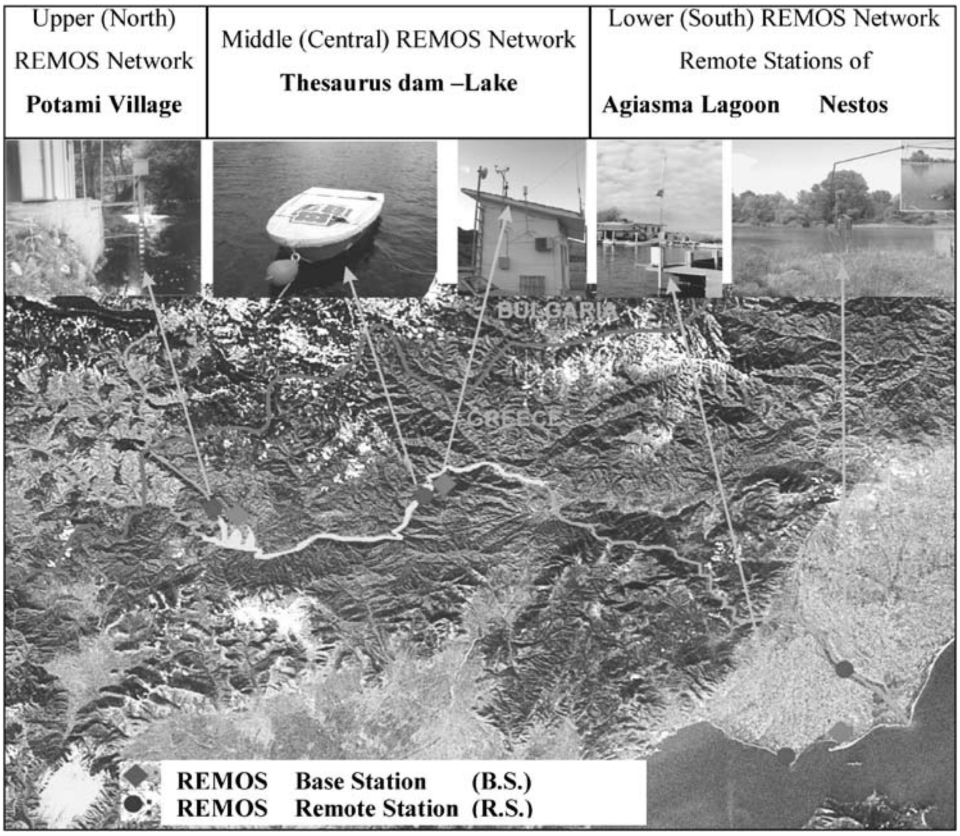

Figure 4. Stations of REMOS Network in the river Nestos.

- Only recently there has been a substantial amount of data that is amenable to such an analysis.

Trend analysis determines whether the measured values of a water quality variable increase or decrease during a time period. Hirsch *et al*. (1991), suggested an adaptation of the Kendall non-parametric test to detect trends in seasonally varying water quality time series (Seasonal Kendall's test). This test can accommodate time series with missing data.

In the present study, to detect the existence of trends in the time series of the variables involved, the nonparametric Spearman's criterion was used and different trend models were fitted (Antonopoulos *et al*., 2001). The Spearman rank-correlation coefficient is described as:

$$R_{sp} = 1 - \frac{6 \cdot \sum_{i=1}^{n} (D_i \cdot D_i)}{n \cdot (n^2 - 1)} \quad (1)$$

where n: is the total number of values in each time series, D: is the difference and i: is the chronological order number.

The difference between rankings is computed as $D_i = K_{xi} - K_{yi}$, where: K_{xi}: is the rank of a measured variable in chronological order and K_{yi}: the series of measurements transformed to its rank equivalent, by assigning the chronological order number of a measurement in the original series to the corresponding order number in the ranked series, y (Antonopoulos *et al.*, 2001).

The null hypothesis, H_0:$R_{\mathrm{sp}} = 0$ (there is no trend), against the alternate hypothesis, H_1:$R_{\mathrm{sp}} <$ or > 0 (there is a trend), is checked with the test statistic:

$$t_t = R_{sp} \cdot \left[\frac{n-2}{1-R_{sp}^2} \right]^{0.5} \tag{2}$$

where t_t: has Student's t: distribution, with $N = \eta - 2$ degrees of freedom. At a significant level of 5%, the time series has no trend if

$$t\{N, 2.5\%\} < t_t < t\{N, 97.5\%\} \tag{3}$$

The trend analysis applied here was an attempt to fit the following models to the time series of the water level and the water quality parameters:

$$\text{Linear model} \quad F = a + b \cdot T \tag{4}$$

$$\text{Quadratic model} \quad F = a + b \cdot T + c \cdot T^2 \tag{5}$$

$$\text{Logarithmic model} \quad F = a \cdot \ln(T) + b \tag{6}$$

$$\text{Power model} \quad F = a \cdot e^{b \cdot T} \tag{7}$$

$$\text{Hyperbolic model} \quad F = a \cdot T^b \tag{8}$$

The best-fitted model of time trend for each variable was chosen using the following statistical criteria of:

$$\text{Mean Error (ME)} \quad \mathrm{ME} = \sum_{i=1}^{n} \frac{e_i}{n} \tag{9}$$

$$\text{Mean Square Error (MSE)} \quad \mathrm{MSE} = \sum_{i=1}^{n} \frac{e_i^2}{n} \tag{10}$$

$$\text{Mean Absolute Error (MAE) and} \quad \mathrm{MSE} = \sum_{i=1}^{n} \frac{\left| e_i^2 \right|}{n} \tag{11}$$

$$\text{Mean Absolute Percent Error (MAPE)} \quad \mathrm{MAPE} = \sum_{i=1}^{n} \frac{\left| X_i - \frac{F_i}{X_i} \right| \cdot 100}{n} \tag{12}$$

where X_i: is the measured value at time i, F_i: is the predicted value at the same time, $e_i = X_i - F_i$, and n: is the number of measurements.

The closer the average ME is to zero and the smaller the values of MSE, MAE and MAPE, the better the model fits the time-series (Antonopoulos *et al*., 2001).

4. Results of Monitoring and Analyzing Data

4.1. Monitoring data of Nestos remote station

The recorded data of Nestos Remote Station (Figure 5) are presented as daily averages of monitored parameters every two hours, for the entire measuring time of three years (1/1/2000–31/12/2002). They are considered as the basic and important ones for the river water, the natural processes, the ecology of the river and its broader area of the deltaic wetland. Although the operation time of the three years is inadequate to reveal river natural processes, the so far collected data seems to contribute in the clarification of the river annual fluctuations after the dam construction and operation. The collected data for three years are briefly summarized below (Psilovikos *et al*., 2005).

The hydroperiod of the river (Figure 6) have not yet been normalized. The annual curves present several fluctuations through the year. Their forms are also different from year to year. During the year 2000 the maximum water level obtained in April

Figure 5. The "Nestos Remote Station" of the lower network of stations in Nestos Delta close to Chrysoupolis.

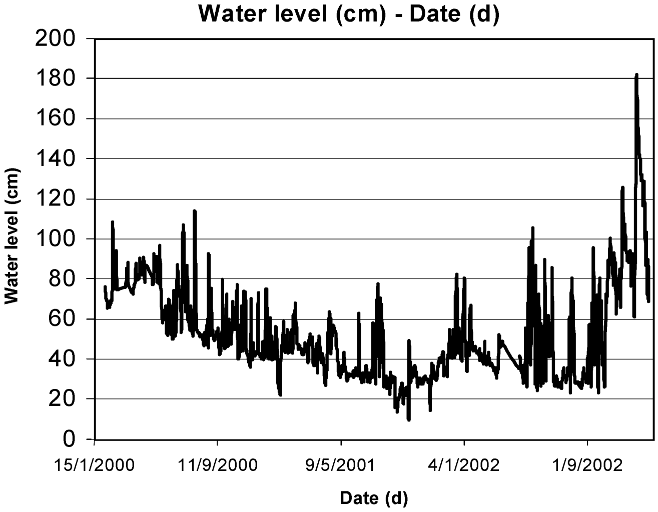

Figure 6. The hydroperiod of Nestos/Mesta the natural River the last three years of measurements dam (2000–2002) in terms of water level (cm).

and the minimum one in November. In the summer months July and August was much higher than expected. During the year 2001 the water level remains low all through the year with maximum values in February–April, July and December. Low values appear in May and September–October. During the year 2002 the maximum values reached in December, a period of successive flooding episodes, while the minimum values reached in the period June–August.

The mean annual recharge of Nestos, prior to the dam construction, had maximum values at the end of April and minimum values at the end of August (Figure 7). It is therefore clear that the present river Nestos tends to establish its new hydroperiod, which seems to have retained its general trend, but minimized the differences between wet and dry seasons (Psilovikos *et al*., 2005).

The water temperature annual curves of Nestos (Figure 8) follows similar forms with the air temperature annual curves (Figure 9). Maximum values appear in early August, while minimum values appear in December–January, of each year for both air and water of the deltaic platform of Nestos. In natural conditions the water temperature has also higher values in winter time and lower values in summer time, in relation to the air values. The difference is normally 3–5 °C of the daily temperature values. The recorded data indicate a daily average of water temperature 2–5 °C higher in wintertime, as well as 5–7 °C lower in summer time, comparing to the air temperature of the area. In April and November the temperature values of the air and water of Nestos are coincide. Of course, the absolute values present greater differences that in summer time reach 10 °C to 15 °C. The river water seems to keep its low temperature leaving the dams and increased slightly along its 65 km course up to the deltaic channel.

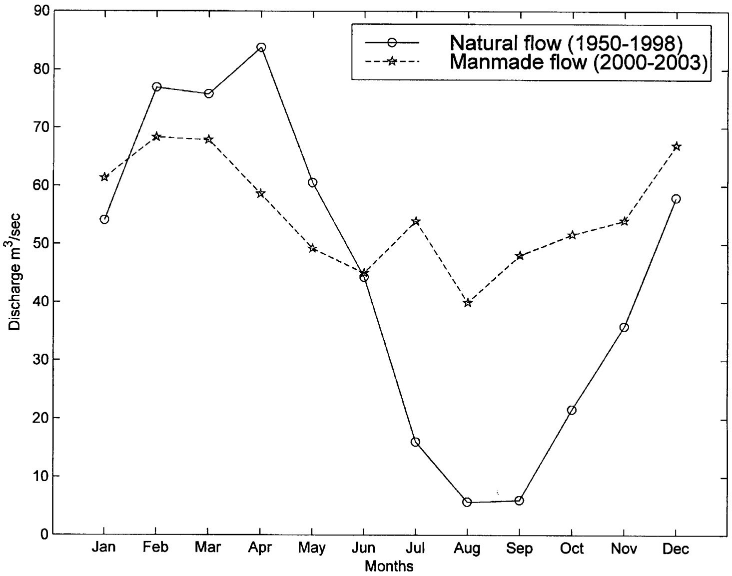

Figure 7. Comparison between hydroperiod of Nestos, prior to the construction and the new human effected hydroperiod, based on discharge (m^3/s) data from DEH.

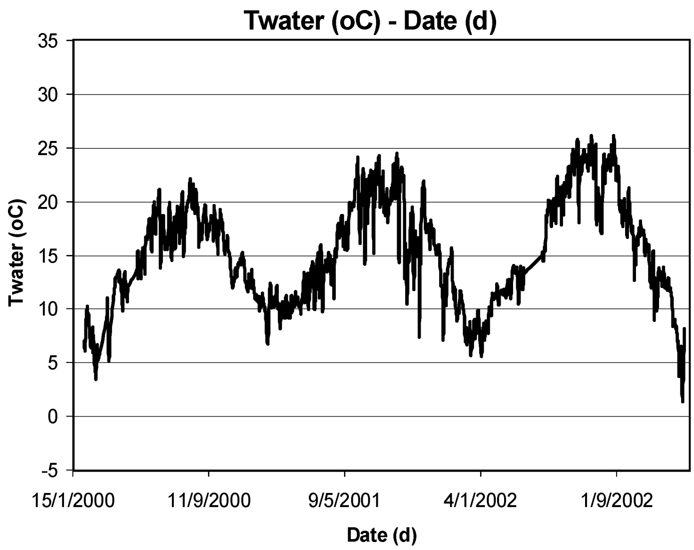

Figure 8. Time fluctuation of water temperature.

The dissolved oxygen in the water was satisfactory all through the measured period in Nestos water (Figure 10). The usual range of values is between 8 mg/L and 12 mg/L. In certain cases were recorded low values 5–6 mg/L, or high values over 12 mg/L. Even in periods of low water level the dissolved oxygen in Nestos water remains satisfactory.

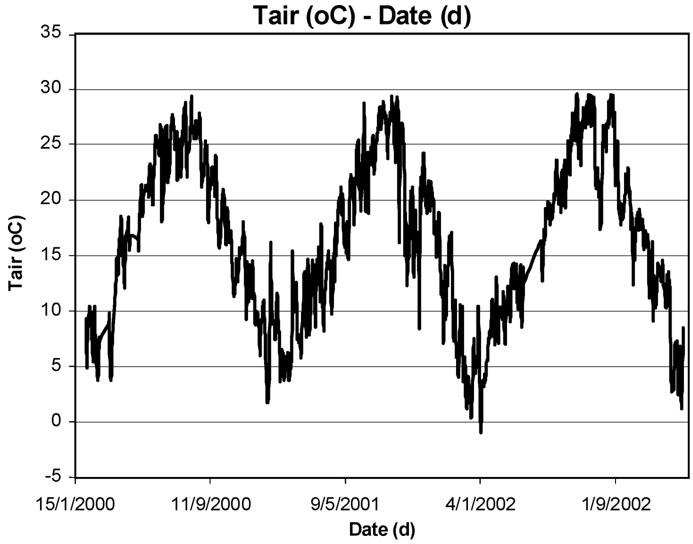

Figure 9. Time fluctuation of air temperature.

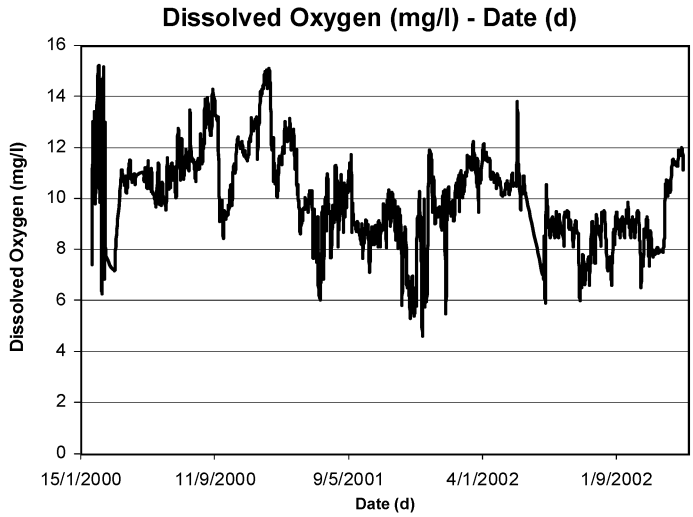

Figure 10. Time fluctuation of dissolved oxygen.

The water conductivity of Nestos has generally low values between 170 and 330 μS/cm all through the year (Figure 11). Within this range the conductivity curves have certain fluctuations. Exceptional values of conductivity of about 100 μS/cm appeared in September of 2001 and December 2002. These low values, seem to coincide with high values of water level and discharge. The water conductivity of Nestos on its deltaic platform, just before the river mouth, indicates its good quality in terms of dissolved material.

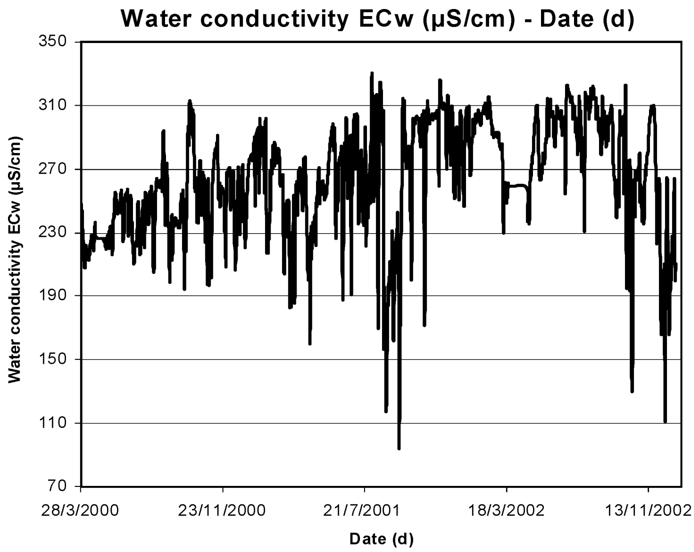

Figure 11. Time fluctuation of water conductivity.

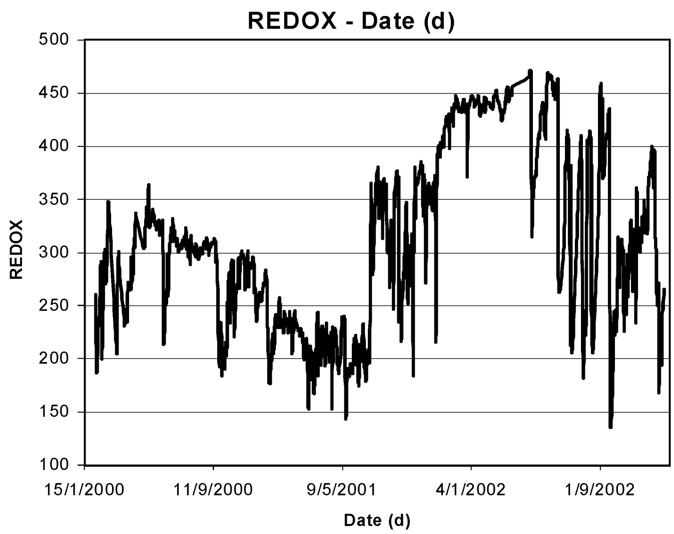

Figure 12. Time fluctuation of REDOX potential.

The Redox potential of Nestos has values from 150 to 450 mV (Figure 12). The lowest values are in May 2001 and September 2002 and the greatest values are in June 2002. The fluctuation of the curves and the correlation with the other quality parameters needs further study.

TABLE I
Trend examination in “Nestos Station” water quality variables. Significance level = 5%

Variable	Number of observations “N”	R_{sp}	tt	Is there a trend?
H (cm)	986	−0.19	−6.06	Yes
DO (mg/l)	978	−0.45	−15.64	Yes
ECw (μS/cm)	986	0.47	16.78	Yes
REDOX	946	0.42	14.29	Yes

4.2. Trend analysis of the monitored data

The daily time series of three quality parameters and the water level of the Nestos River at the “Nestos Remote Station” were tested for existence of trends by using the nonparametric Spearman’s criterion and analyzed by fitting different trend models. The value of Spearman’s rank correlation coefficient (Equation (1)), the Spearman’s statistical criterion (Equation (2)) and the limits defined by Equation (3), are given in Table I. For three years of daily monitoring N should have been equal to $3 \times 365 = 1095$, but the actual values of N are from 946 (Redox) to 986 (ECw and Water level). This happened because it took about the first three months of the year 2000, for the complete installation of the stations and calibration of the sensors.

So, according to the results of the Spearman’s test, the values of the observed time series changed over time in a certain rate. These changes can be described by best-fitting one of the known trend models (Equations (4)–(8)) to each one of the data time series. The selection of the “best-fitted” model was based on the values of the statistical tests described by Equations (9)–(12) and are given in Table II. The graphs with the observed values of the data time series and the curves of the best-fitted trend models are shown in Figures 13–16 for the water level, dissolved oxygen, conductivity and redox respectively.

The conclusions deriving from the previous trend analysis are:

- The second order equation (Equation (5)) describes the trend of the data time series better than the other used models,

TABLE II
Trend models which describe best the trends of the Nestos water quality variables, with the values of the statistical tests

Variable	Model	ME	MSE	MAE	MAPE
H (cm)	$0.0002 \times T^2 - 0.2293 \times T + 100.97$	−0.86	364.11	13.75	5075.10
DO (mg/L)	$0.000002 \times T^2 - 0.0056 \times T + 12.28$	−0.02	2.26	1.13	816.12
ECw (μS/cm)	$-0.00012 \times T^2 + 0.1985 \times T + 202.48$	0.26	1122.86	23.96	24266.03
REDOX (mV)	$-0.0000003 \times T^2 + 0.1526 \times T + 236.87$	3.09	5562.50	64.81	31107.08

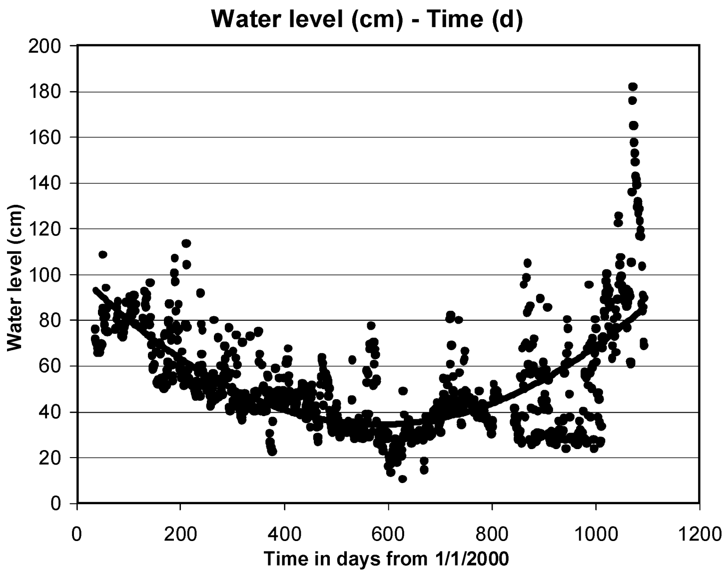

Figure 13. Daily measured values of water level (H – cm) and the curve of the best fitted trend model.

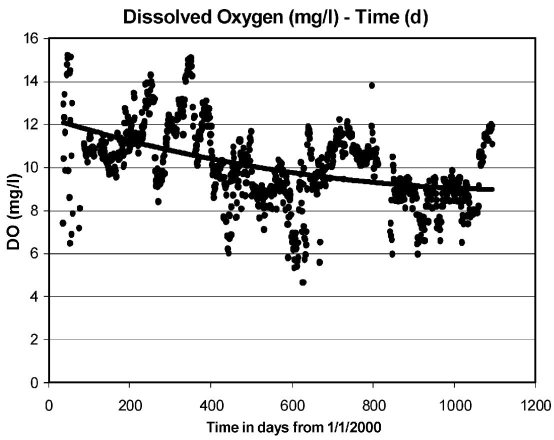

Figure 14. Daily measured values of dissolved oxygen (DO – mg/L) and the curve of the best fitted trend model.

- The trend of water level (H) is downwards from the beginning to the 573rd day and upwards from the 573rd day to the end (Figure 13).
- The DO has a downwards trend to the predicted value of DO $= 8, 70$ (for $T = 1095$ days) and the minimum predicted value of DO = 8.36, which would be achieved for $T = 1400$ days (Figure 14).

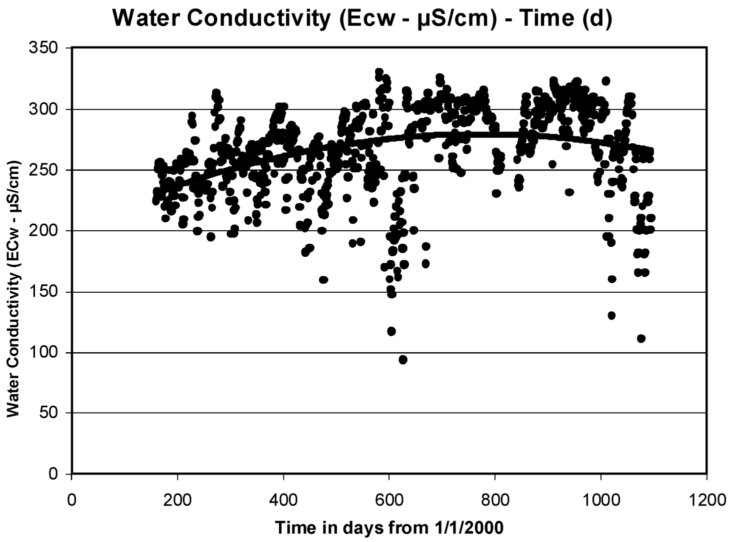

Figure 15. Daily measured values of water conductivity (ECw – μS/cm) and the curve of the best fitted trend model.

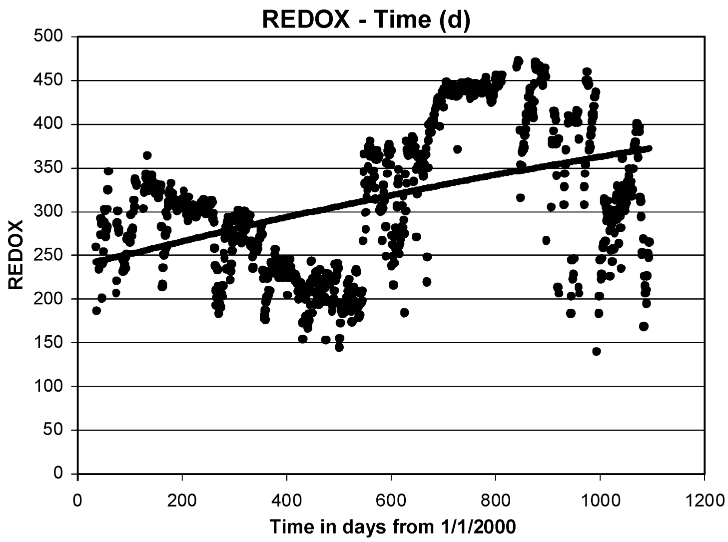

Figure 16. Daily measured values of REDOX and the curve of the best fitted trend model.

- The trend of the ECw is upwards from the beginning to the 827th day and downwards from 827th day to the end.
- The Redox has an upward trend (Figure 16), but the three years monitoring data are not enough. So, further study is needed to clarify redox trend.

5. Conclusions

There is continuous water flow in the deltaic channel of Nestos all through the year. However the natural hydroperiod of the river have been changed (Psilovikos *et al.*, 2005). The curve has not yet been normalized and presents several fluctuations through the year. The important change occurred in summer time by the increase of water level in the channel. This increase is related to the increase in power production in the Hydroelectric Stations of DEH to satisfy the increasing energy needs (e.g. increase air conditioners) of the broader area. This is a new phenomenon in Hellas that shows how the change of life conditions influence the river flow in case of regulated rivers (Nestos, Aliakmon, Acheloos, etc.). The daily fluctuations of the water level are also an interesting parameter for further analysis to the point they influence the ecological conditions of the deltaic platform.

The water temperature follows similar annual curves with that of the air temperature. The two curves coincide in April and November. In wintertime they differ 2–5 °C in favour of water, while in summer time they differ 5–7 °C in favour of the air. The temperature differences between water and air of Nestos deltaic channel during the summer period, seems to be also important. The explanation comes through the measurements of water temperatures in the dams (Moustaka–Gouni *et al.*, 2000). The water released from the dams has very low temperatures (6–12 °C) and it is not able to reach normal values (warm up) in its 65 km downriver flow, up to the REMOS Station of the deltaic platform (Albanakis *et al.*, 2001) particularly in summer time when the natural water temperature exceed 20–25 °C. The construction of the lowest dam of Temenos as it was originally scheduled by DEH, should have positive effects in the future in normalizing both the water flow and temperature up to the deltaic platform.

The quality of water in terms of ECw and DO remains in very good levels. The ECw values are between 170 and 330 μS/cm all through the year. Within this range the ECw curves have certain fluctuations. Usually, low values seem to correspond with high values of water level and discharge. The water conductivity of Nestos on its deltaic platform, just before the river mouth, indicates its good quality in terms of dissolved material.

It is difficult to evaluate and clarify the Redox potential data that needs further study.

Trend analysis was carried out for the daily measured values of three quality variables (ECw, Redox and DO) and the water level (H) in "Nestos Station". Variation in the above water quality parameters are strongly related with time. The non – parametric Spearman's criterion was used to analyze for trends for a period of three years and specifically from 1/1/2000 to 31/12/2002. The Spearman's test detected trends for the quality parameters below and the second order equation provided a better description of the trends of these variables. (Antonopoulos and Papamichail, 2002). The samples were very dense time distributed and results obtained for the quality parameters below:

- The water level has a downwards trend from the beginning to the 573rd day and an upwards trend from the 573rd day to the end.
- The dissolved oxygen has a downwards trend to the predicted value of DO $= 8.70$ which is achieved at the end of the monitoring period ($T = 1095$ days).
- The water conductivity has an upwards trend from the beginning to the 827th day and a downwards trend from the 827th day to the end. The trend of water level is related inversely with the trend of conductivity. In this case the increase of water level causes decrease of the conductivity and vice versa.
- The redox potential has an upward trend all over the three years monitoring time, but it is not clearly related with the trend of water level. This requires further research.
- Even though the DO has a downward trend, the minimum predicted value of 8.70 is considered as satisfactory value for the ecological preservation in the delta natural processes.

6. Discussion

The Nestos Scheme serves many purposes and so requires management for maximum efficiency. Energy production from the hydropower stations in the dam lakes of Thesaurus and Platanovrysi, water for irrigation of the fertile deltaic plain, water for fisheries, coastal zones and deltaic lagoons as well as water for the environment along the river valley and the deltaic platform, are some of the component parameters of natural and anthropogenic aquatic system of Nestos that requires multiobjective management for sustainable development.

The construction and operation of the multipurpose dams of Thesaurus and Platanovrysi in the intermountain valley of Nestos, as well as of the irrigation dam Toxotes at the deltaic head, seems to have influenced certain quantitative and qualitative parameters of its water in the deltaic channel. This can be attributed to the management practices applied by DEH in the hydroelectric stations, as well as by the Agricultural Services in the irrigation dam of Toxotes.

From the monitoring and the analysis of the water quality parameters, it is obtained that the so far applied river management of DEH seems to have positive effects for the water quality, which in turn influences the river and the deltaic ecological conditions downwards to the Thracian sea. The so far known human works and other activities in the drainage basin and the deltaic plain of Mesta/Nestos River during the last 50 years (Psilovikos, 1992) brought serious changes in the river regime and the natural environment. To clarify these changes and evaluate their role in the ecology of the river and the deltaic system, further research is required in the future concerned on:

1. Installation and operation of new monitoring stations up to the Bulgarian part of the drainage basin of Nestos,

2. Longer monitoring period of time and
3. Higher level of statistical analysis and simulation with water quality models.

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