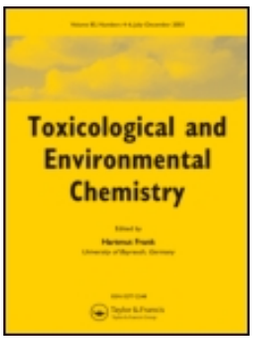

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NITRATE CONTENT OF SURFACE AND GROUND WATERS OF NORTHERN GREECE

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The extent of NO_3 pollution of natural waters of Northern Greece was evaluated by collecting and analyzing representative samples, covering the whole area of interest, from (a) rivers of Axios, Aliakmon, Loudias, Strymon, Nestos and Evros; (b) lakes of Vegoritis, Volvi, Agh. Vasiliou, Visthonis, Trichonis and Doirani and (c) urban drinking waters along with irrigation waters from water-wells of the area. Nitrate determination was performed potentiometrically with a nitrate ion selective electrode. Several samples were found to contain significant amounts of nitrate ranging from 50 to 100 mg/l. An explanation about the origin of nitrites in some of the samples is given and a discussion of the harmful effects of nitrates to the environment is reported.

INTRODUCTION

The presence of nitrates in surface and ground waters has recently received considerable attention due to nitrate serious effects on human health and natural waters quality. Years ago Comly[1] showed first that high concentrations of nitrates in drinking water could be a cause of cyanosis (methaemoglobinaemia) in babies during the first ten weeks of their life, since they are artificially fed with milk made up with this water or given water of this quality to drink. The problem is focused mainly to infants because there is a high fluid intake in the newborn proportional to the body weight. Since there is no simple method of treating the polluted water, such as boiling, much care has to be taken with the water consumed by infants. According to the Committee of the Division of Medical Science of the U.S. National Research Council,[2] the waters from private wells containing more than 45 mg/l of nitrates should be regarded unfit for the babies.

However, concerning the importance of nitrates with respect to the surface water quality, it stems primarily from its ability to stimulate algae and other aquatic plant growths resulting in eutrophication of the surface waters with the well known dramatic effects on their ecosystems.

Nitrate pollution is more pronounced in agricultural areas with heavy nitrogen fertilization. Organic wastes are also responsible for nitrate pollution of natural waters, whereas soil organic matter and precipitation contribute to a lesser extent. Due to the extreme high solubility of the nitrate salts, they are easily leached from the soil and transferred by rainfalls into the surface and ground waters. Finally they get into our body by drinking water. In France, it has been calculated that from the total amount of nitrates applied to the soil, every year, 20% is leached and removed by the rainfalls.[3]

Besides, nitrate accumulation in ground environment is well known to depend on many factors, independent from human activities, like the texture of the soil, the geological morphology of the area, the frequency of the rainfalls, the climate conditions and others.

Nitrate content of natural waters not affected by pollution is usually less than 10 mg/l. Nitrate values reported as toxic, have been found to be more than 90 mg/l expressed as NO_3. The critical level appears to be 10–20 mg/l expressed as $N\text{-}NO_3$ or 45–90 mg/l expressed as NO_3, whereas International Standards for drinking water[4] give 45 mg/l and European Standards for drinking water 50 mg/l as NO_3, levels above which trouble may arise.[5] In this work we tried to evaluate the extent of nitrate pollution of natural waters, by collecting and analyzing representative water samples from rivers, lakes and urban drinking waters along with irrigation waters from water wells of Northern Greece. Several samples were found to contain significant amounts of nitrates, ranging from 50–100 mg/l which is believed to originate mainly from fertilizers and probably from organic wastes of the corresponding area while the kind of soil also plays an important role.

EXPERIMENTAL

Apparatus

An Orion model 901 microprocessor ionalyzer, equipped with a nitrate ion selective electrode[6] and a 90-02 double junction reference electrode were used for the determination of the nitrate concentrations of the water samples.

Procedure

The measurements were carried out on duplicated samples of 10 ml mixed with 10 ml TISAB.[6] While stirring at constant speed and temperature, the potential was measured and nitrate concentration was found through the calibration curve obtained with standard solutions.

Collection of the Samples

The collection of the lake water samples was carried out from the surface of the lake up to 1 m depth. River water was sampled from the center of the river over the bridge, while the collection of the drinking and well waters was made without any special care. One percent of preservative reagent, boric acid, was immediately added, after sampling, into the container.

RESULTS AND DISCUSSION

Over a period of four months, from May to August 1987, several water samples

were collected from surface and ground waters of the whole area of Northern Greece. Samples were collected from (a) urban drinking water and irrigation waters; (b) lakes Vegoritis, Volvi, Agh. Vasiliou, Visthonis, Trichonis and Doirani, and (c) the rivers of Axios, Aliakmon, Loudias, Strymon, Nestos and Evros. The purpose of this collection was to determine the nitrate content of the waters in order to evaluate the extent of nitrate pollution of the natural waters of the studied area.

The results of the nitrate determined in the three types of water (drinking, lake and river waters) are given in Tables 1, 2 and 3, respectively.

a) Drinking Waters

From the data of Table 1, it can be concluded that from a 159 total number of water samples, 118 samples, i.e. 74%, is beyond the level of 10 mg/l NO_3, which is considered as really negligible quantity, without any problem for the case of drinking water. Nineteen percent was found to be between 10–45 mg/l NO_3, which means that the nitrate content of these waters is not too high but on the other hand it is not negligible as in the previous case. However, the rest of the samples (7%) gave nitrate concentrations higher than 45 mg/l, a value considered as maximum allowable limit for drinking water, according to the international standards of the W.H.O. It is worth mentioning that these waters originate from entirely agricultural areas without any industrial activity.

The geological examination of the areas where high nitrate content was found in their waters, revealed that this high content can be attributed to the easy leaching of the soil and the limited unconfined aquifer where all the lechates end. These high nitrate concentrations of the drinking waters could be decreased by isolating the well waters from the possibly existing unconfined aquifers.

b) Lake Water

As has been reported by other investigators, nitrate concentrations greater than 1.3 mg/l in a lake, may allow excessive algal growth. From the latest EPA guideline,[7] it can be seen that for nitrate (3.3 mg/l), it is 2.5 times the accepted limit above which excessive algal growth may occur. This value of 3.3 is considerably less than the 45 mg/l NO_3 which is acceptable for drinking water. Thus, it is concluded that water quality standards for the control of eutrophication are more stringent than for those of drinking water. From the data of Table 2 it is clear that the lakes Visthonis and Vegoritis are highly polluted by nitrates, while the nitrate content of the lakes Doirani and Trichonis is too low. For the lakes Volvi and Agh. Vasiliou the problem starts rising since the values obtained are at such critical levels, so that extra care is needed in order to prevent, if possible, the destruction of any life left in the lakes. So, for these two lakes it is suggested to start a more complete study for better understanding of the real situation of pollution.

Table 1 Nitrate concentrations of drinking and irrigation waters from different areas of Northern Greece

Sampling area	*Concentration in mg/l NO_3*	*Sampling area*	*Concentration in mg/l NO_3*
Thessaloniki district			
Thessaloniki	1.8	Sohos	43.1
Stivos	0.5	Xyloupoli	1.0
Lahanas	101.2	Liti	18.5
Agh. Vasilios	7.1	Redina	2.5
Stavros	3.3	Asprovalta	2.5
Evagelistria	58.9	Dorkada	9.5
Assiros	0.6	Lagadikia	9.5
N. Efkarpia	43.5	Souroti	34.5
Serres district			
Serres (center)	14.5	Serres (R.S.)	3.5
Agh. Pnevma	0.9	Emm. Papas	75.6
Pentapoli	46.7	Hrisos	34.4
Gazoros	63.7	Tholos	32.2
Melenikichio	2.2	Vamvakofito	76.1
Kato Ambela	0.5	Agh. Ioannis	1.4
Sidirokastro	0.3	Paliokastro	0.3
Provatas	0.7	Hristos	2.9
Valtero	5.0	Skotousa	0.6
Iraklia	1.0	Ammoudia	3.9
Pontismeno	1.2	Strymonohori	5.1
Lithotopos	3.7	Kala Dentra	1.1
Kalokastro	16.2	Leukonas	1.7
Haropo	50.7	Gefiroudi	20.1
Mandraki	0.3	Leukothea	57.7
Alistrati	36.1	Mesorahi	15.2
Mavrothalasa	0.3	Eleonas	1.9
Paliokomi	4.6	Iliokomi	49.2
Mesolakia	16.6	Kefalohori	3.6
Sidirokastro[a]	1.4	Nigrita (mineral)	2.1
Agistro[a]	1.1	Agistro	1.2
Halkidiki district			
Nikiti	6.2	Triglia	4.5
Agh. Nikolaos	1.5	Metamorfosi	5.6
Vourvourou	0.8	N. Sillata	5.3
Moudania	41.7	Kalives	6.5
Vatopedi	7.5	Doubia	3.1
Kavala district			
Kavala	4.0	Eleftheroupoli	3.5
Mesoropi	0.5	Platanotopos	1.0
Karvali	4.0	Paradisos	2.6
Kalorahi (Thasos)	4.3	Krinides	8.5
Panagia (Thasos)	1.2	Krinides[a]	2.3
Limenaria (Thasos)	6.1	Nikisiani	0.3
Evros district			
Alexandroupoli	6.5	Ferres	8.2
Provatonas	2.1	Orestiada	4.7
Didymotiho	15.3	Soufli	5.8
Anthia	7.5		

Table 1 (continued)

Sampling area	*Concentration in mg/l NO_3*	*Sampling area*	*Concentration in mg/l NO_3*
Pella district			
Edessa	3.5	P. Pella	30.1
Klisohori	2.8	Aridea	7.8
Apsalos	6.4	Lipohori	19.4
Mavrobouni	37.1	Kali	4.8
Milea	5.2	Gypsohori	10.4
Paliofito	8.8	Polikarpi	5.9
Mandalo	38.6	Theodoraki	1.1
Skidra	15.6	Kariotissa	6.0
Drosero	14.5	Trifili	9.8
Piperia	8.1	Karidia	2.8
Anidro	11.9	Agras	2.8
Pr. Ilias	31.5	Exaplatanos	9.6
Giannitsa	3.1	N. Milotopos	11.9
Galatades	2.1	Pozar	0.3
Melissi	1.5	Pozar[a]	0.9
Imathia district			
Veria	7.8	Rizomata	0.6
Patrida	4.7	Patrida (spring)	102.8
Kopanos	29.7		
Kozani district			
Kozani	11.2	Kerasia	5.5
Ptolemaida	0.8	Tetralofos	3.4
Voskohori	3.2	Lefkovrisi	20.2
Elatos	0.4	Doxara	0.8
Florina district			
Florina	3.2	Andartiko	0.4
Drosia	6.1	Valtonera	0.9
Limnohori	1.7	Agh. Anargyri	0.8
Agrapidia (spring)	152.7	Xyno nero (mineral)	2.1
Volos district			
Volos	8.9	Agia	2.5
Aghialos	16.2	Kalamaki	6.2
Larisa district			
Larisa	4.5	Melivia	3.3
Amygdali	5.2	ELVAK S.A.	3.1
DEL MONDE S.A.	2.2		
Drama district			
Drama	9.5	Sitagri	6.9
Argyroupoli	7.8	Mavrolefki	5.5
N. Amissos	2.1		
Xanthi district			
Xanthi	9.8	Tymbano	1.1
Vafeika	14.3	Stavroupoli	0.5
Koutso	14.5		
Rodopi district			
Komotini	8.5	Sappes	12.8

[a]Thermal spring.

Table 2 Nitrate concentrations[a] of lake water from Northern Greece

Lake	*NO_3 concentration in mg/l*
Trichonis	0.4
Vegoritis	7.9
Doirani	0.5
Volvi	1.6
Agh. Vasiliou	5.1
Visthonis	18.5

[a]The mean value of three samples.

Table 3 Nitrate concentration (mg/l NO_3) of the river waters of Northern Greece

River	*Collection date*			
	1/5/87	*3/6/87*	*20/6/87*	*8/7/87*
Aliakmon	0.8	7.0	13.1	8.4
Loudias	22.1	5.6	9.2	4.1
Axios	4.0	3.9	7.2	3.9
Strymon	2.6	2.2	3.1	4.5
Nestos	2.3	2.6	2.9	2.5
Evros	4.5	7.3	6.5	6.1

c) River Water

In Table 3, the results of nitrate determination in the river water samples are given. As is shown, the samples were taken approximately once a month and from the same point each time. From the above results, it can be seen that except for the rivers of Nestos and Strymon, which contain nitrates less than 5 mg/l, all the others contain between 5 and 10 mg/l of NO_3, which could not be considered as negligible. Although, in this case we cannot apply so easily the definition of eutrophication, each river involved in the aquatic sphere, forms a defined biotope which can be considered as a particular ecosystem and has to be studied as such.

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