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STUDY CONCERNING THE EVOLUTION OF NITRATE CONCENTRATION IN GROUNDWATER BY MEANS OF GIS TECHNIC

BY

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Abstract. In the present paper, we try to emphasize the increase of the content of nitrates and nitrites from the underground waters, in direct correlation with the manner of exploitation of agricultural lands and implicitly the levigated quantity of azoth, using the modeling method through the GIS technique.

Both the physical pollution through processes such as: hydric or wind erosion, the destructuring, compacting etc.) and chemical pollution through the alluvial transport with significant pesticide quantities, contribute in this manner even more to sensitizing, favoring and emphasizing the degradation of the quality of underground waters, considered as being "*the last hope of drinkable water*".

Key words: underground waters, model MNT, software Surfer, GIS.

1. Introduction

The activity of studying groundwater quality is carried out at the level of large water basins, according to morphological units and within these units according to aquifer structures (underground), by means of hydrogeological stations, including one or more *drillings for observation.*

The most probable causes for which phreatic water does not meet the requirements for drinkable water are:

a) pollution of surface water;

b) hydrogeochemical natural conditions and processes which favor the contamination with various anions and cations;

c) the boom of agriculture during last decades and the excessive use of pesticides, chemical fertilizers with nitrogen and phosphorous as main components determined the accumulation of some of these substances (or their decomposition products) in the soil;

d) the outcomes of the lack of responsibility of former large animal farms with respect to environment preservation measures;

e) climatic, hydrogeological features and the use of irrigation systems which brought about the mineralization of organic matter of soil and the migration of substances resulting from these processes.

A special issue connected to groundwater quality is its nitrate (nitrogen-NO_3) contents.

The quality of groundwater is considered suitable if its quality indices are comprised within the maximal allowed concentration, enforced under Water Law 410/2002 amended and completed by Law 311/2004.

The main sources of nutrient collection are direct spills from agriculture, leakages and erosion and also the effluents of water treatment plants. It is anticipated that most nutrient uptake is due to agricultural sources (wide sources).

The widespread pollution caused by agricultural land is still the main source of nitrate content in water. Nitrates continue to bring about damages to the environment, determining the eutrophication of coastal and sea waters and the pollution of drinkable water, especially in those areas where groundwater was polluted.

Groundwater is drinkable provided that the value of NO_3 index should be below the maximal allowed concentration enforced through the Water Law (NO_3-50 mg/l).

2. Case Study

The groundwater of Prut river basin is blocked within porous permeable deposits from the Quaternary and Tertiary period which are on top of even older formations from Cretaceous, Silurian and even Pre-silurian, lying at various depths, but due to climatic conditions and on account of these layers, it has a decreased flow and a high content of salts.

The groundwater from Moldovenesti platform, as far as their natural possibilities of drainage are concerned, in particular their connection to surface waters, are: under pressure (in depth) and phreatic (free).

In the case of Prut river basin, its groundwater is caught in the sandy deposits from the Quaternary period, with clay intertwining of minor hydrogeological significance and gypseous soils. In this context, the water which may be used is found in the river meadow, in poorly permeable and sulphated reserves. Generally speaking, the water is highly sulphated mineralized and hard, and it has a low flow.

Fig. 1 – Locations of hydrogeological stations in Jassy county.

3. Creation of 2D and 3D Information/Thematic Layers About the Distribution of Nitrate Concentrations

As input data we used the nitrate concentrations, determined in the Water Quality Laboratory of Prut Water Department. The tests were conducted on samples of water taken from 23 observation drillings (located through STEREO 70 coordinates) belonging to the National System of Supervision of groundwater quality.

As their assessment is performed by taking water samples from a limited number of drillings which are randomly distributed throughout the territory, only specific data are gathered [1].

Starting from a small number of drillings and respectively, samples, it is only possible to approximate the nitrate concentration throughout the studied territory and it is difficult to develop the most accurate response within due time [2].

This hindrance may be overcome by using a field numerical model based on the spatial design technique.

As drillings are distributed in an ordinate or inordinate area, we can speak about a network pattern or an irregular pattern (triangular). In the network pattern (profile positioning) points coincide with the intersections of a regular grid. Starting from these basic data, nitrate concentration are represented (in my application) in MNT and are usually derived through interpolation. I used the *Surfer* software for this GIS (Figs. 3,…,6).

Table 1
Nitrate Concentration [mg/l] *in Observation Drillings Located through STEREO 70 Coordinates*

forajul \ anul	IND	X	Y	2001	2002	2003	2004
cma				50	50	50	50
BELCESTI	F1	655584,86	647280,55	1,25	1,05	1,23	1,25
BELCESTI	F2	655268,52	646983,47	1,16	1,02	0,89	0,34
BELCESTI	F3	656677,43	646328,63	0,24	0,23	0,20	4,00
BELCESTI	F4	656776,64	646943,79	1,05	0,85	0,50	0,24
CIRNICENI	F1	696082,46	653053,35	0,200	1,20	49,70	2,00
CIRNICENI	F2	693880,40	653097,63	4,000	3,60	25,70	4,70
CIRNICENI	F3	690868,40	653521,56	0,200	16,00	14,20	4,30
CIRNICENI	F5	691156,98	650027,41	1,400	23,30	33,92	5,80
TIBANESTI	F1	679970.07	602429.76	4	14,6	2,77	8
COSTULENI	F1	720455,61	622856,79	0,42	1,10	0,20	1,10
COSTULENI	F2	720268,28	622351,86	1,800	23,50	8,10	1,20
COSTULENI	F3	718504,04	620906,76	1,900	11,40	0,70	4,80
COTNARI	F2	650091,06	652419,80	23,620	21,25	18,45	16,23
COTNARI	F1	649598,92	652002,57	34,62	31,45	23,30	20,23
CRISTESTI	F1	710883,97	637421,06	0,60	137,00	2,00	3,60
CRISTESTI	F4	707342,91	635030,61	0,140	5,90	3,80	0,00
CRISTESTI	F5	706655,71	634513,03	1,000	2,10	74,00	1,30
GLAVANESTI	F2	670076,06	674120,69	192,00	180,00	156,00	142,00
GLAVANESTI	F1	670598,61	674722,62	184,00	167,00	135,00	121,00
HIRLAU	F1	646222,34	658591,02	1,400	8,00	4,74	3,10
IASI	F8	711030,51	631622,38	2,800	6,20	2,09	1,80
IASI	F9	711466,72	634677,51	17,800	3,30	2,04	11,00
TG. FRUMOS	F1	668622,48	656541,32	31,76	23,87	18,78	12,00

From the 12 methods of interpolation provided by the Surfer software I chose to study the evolution of nitrate content of groundwater through Inverse Distance to a Power interpolation method (Fig. 2).

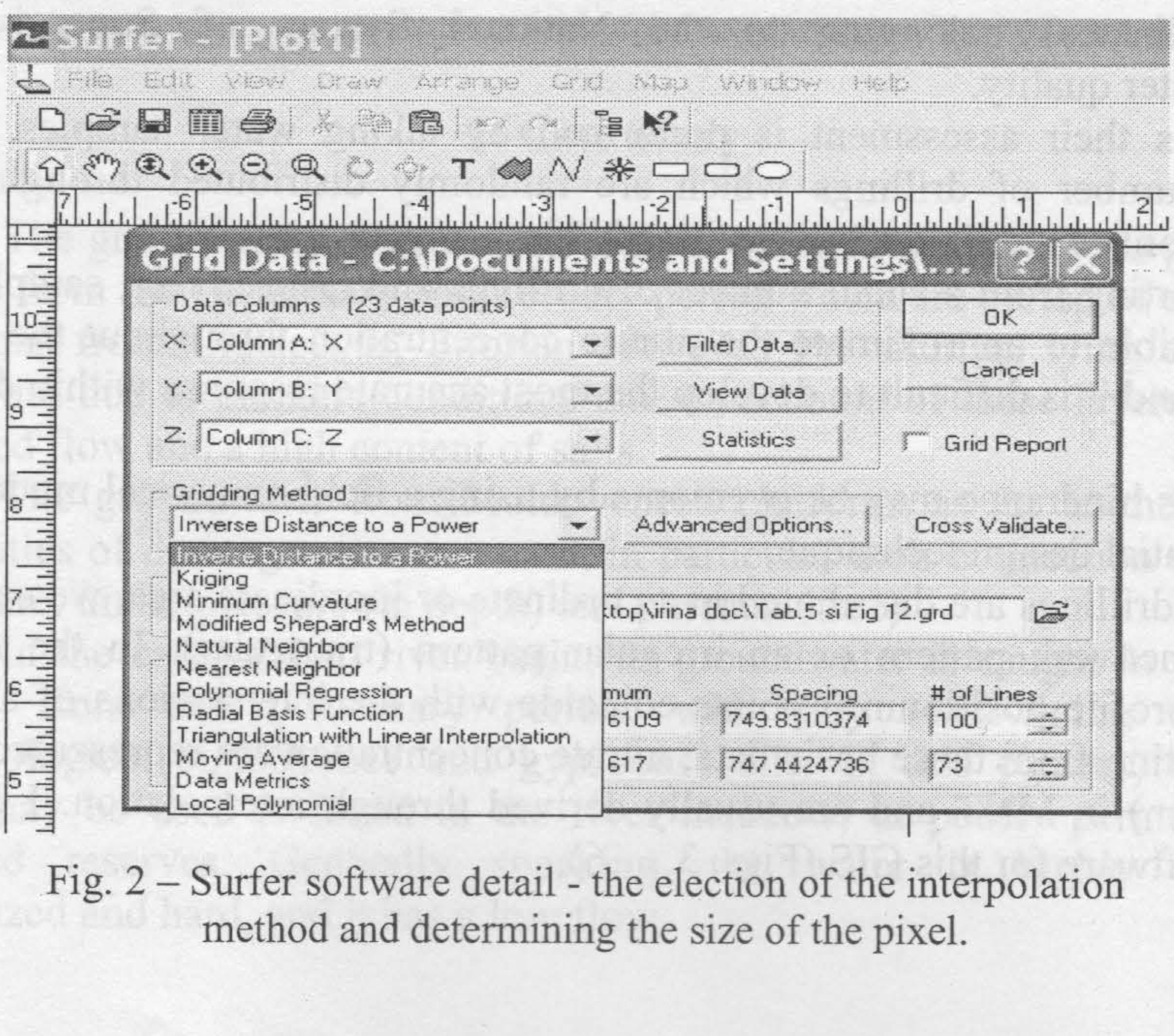


Fig. 2 – Surfer software detail - the election of the interpolation method and determining the size of the pixel.

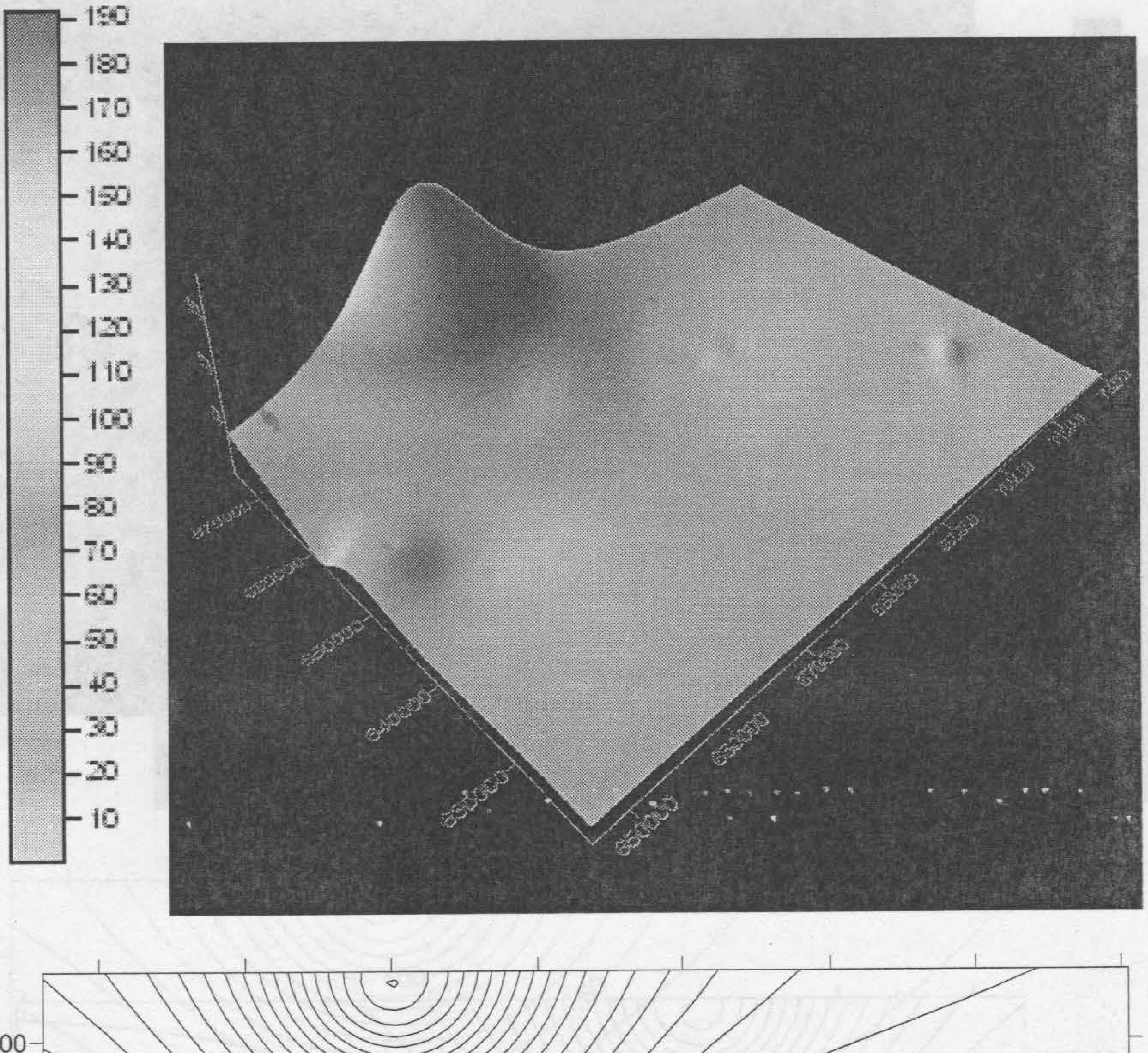


Fig. 3 – Thematic layer for the distribution of nitrate concentration in the studied territory in 2001- 2D representation with isolines and 3D representation.

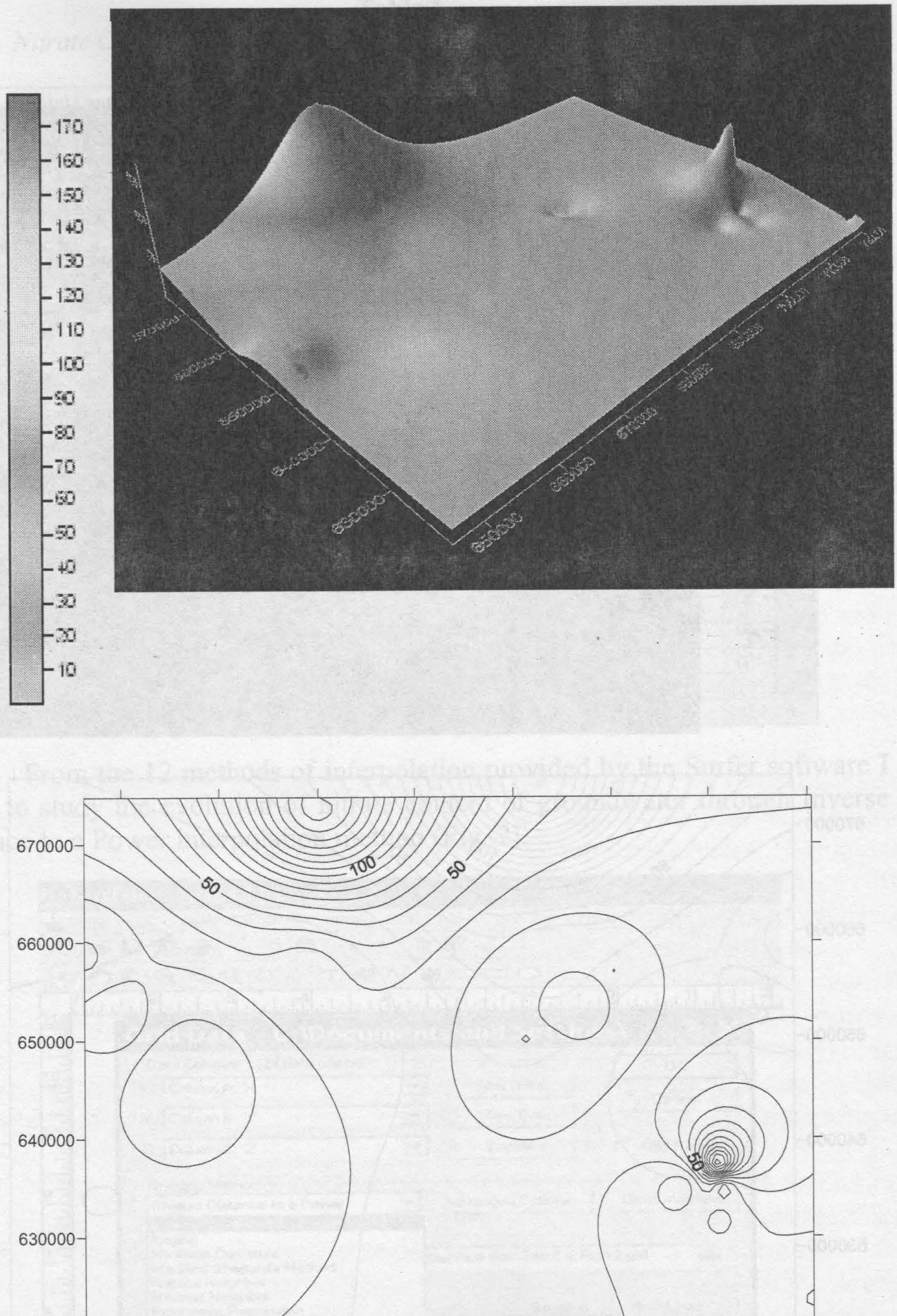


Fig.. 4 - Thematic layer for the distribution of nitrate concentration in the studied territory in 2002- 2D representation with isolines and 3D representation.

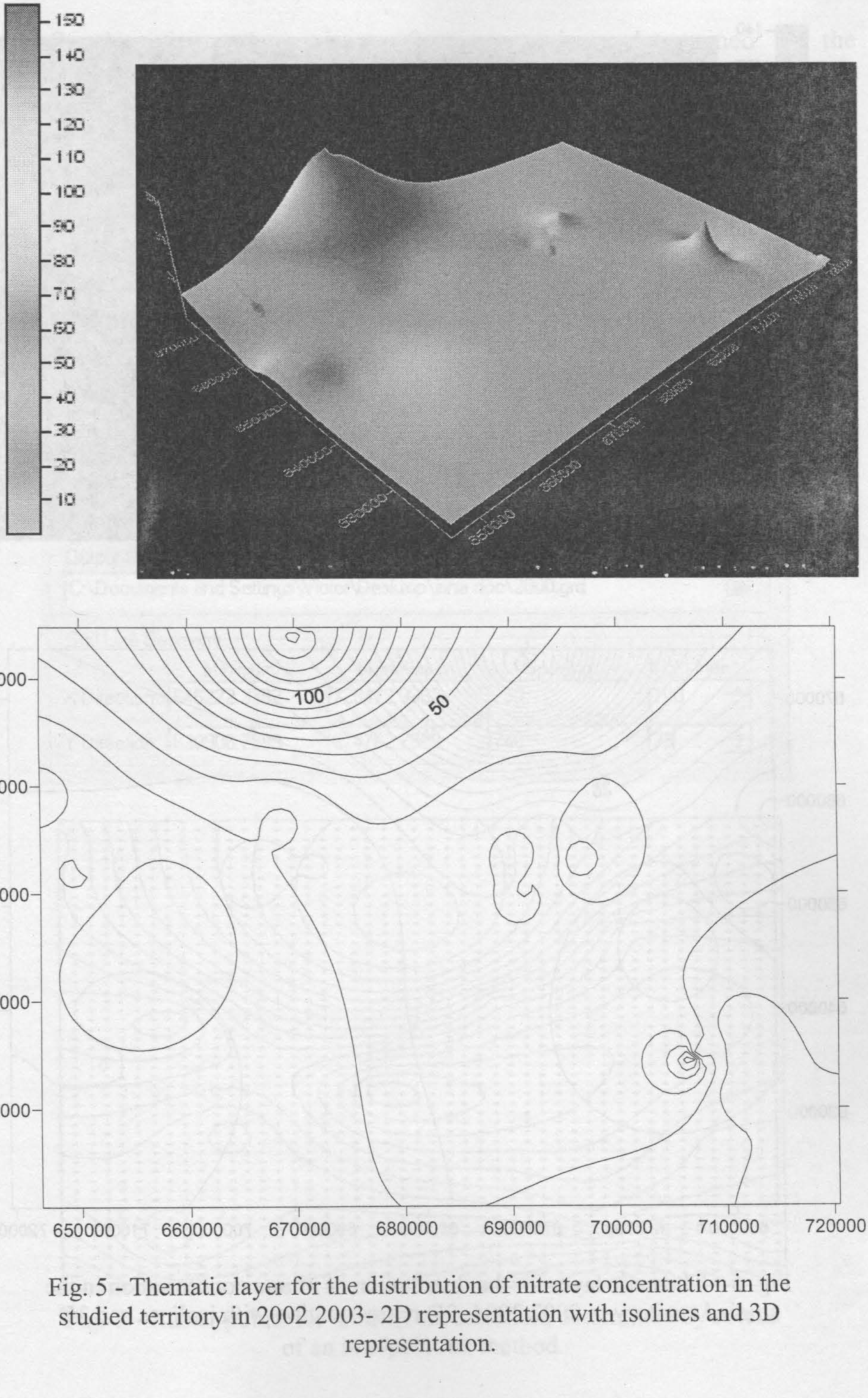


Fig. 5 - Thematic layer for the distribution of nitrate concentration in the studied territory in 2002 2003- 2D representation with isolines and 3D representation.

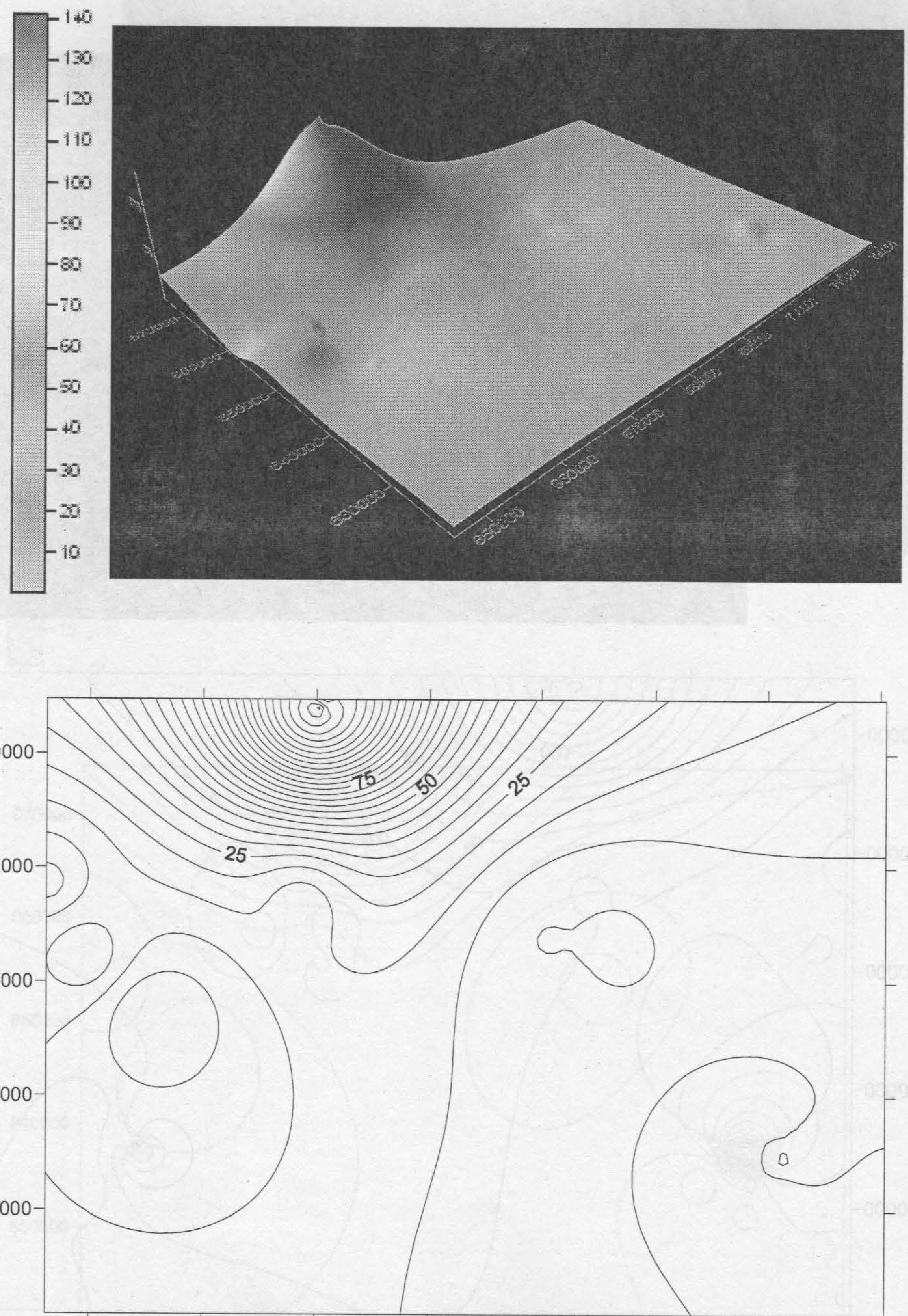
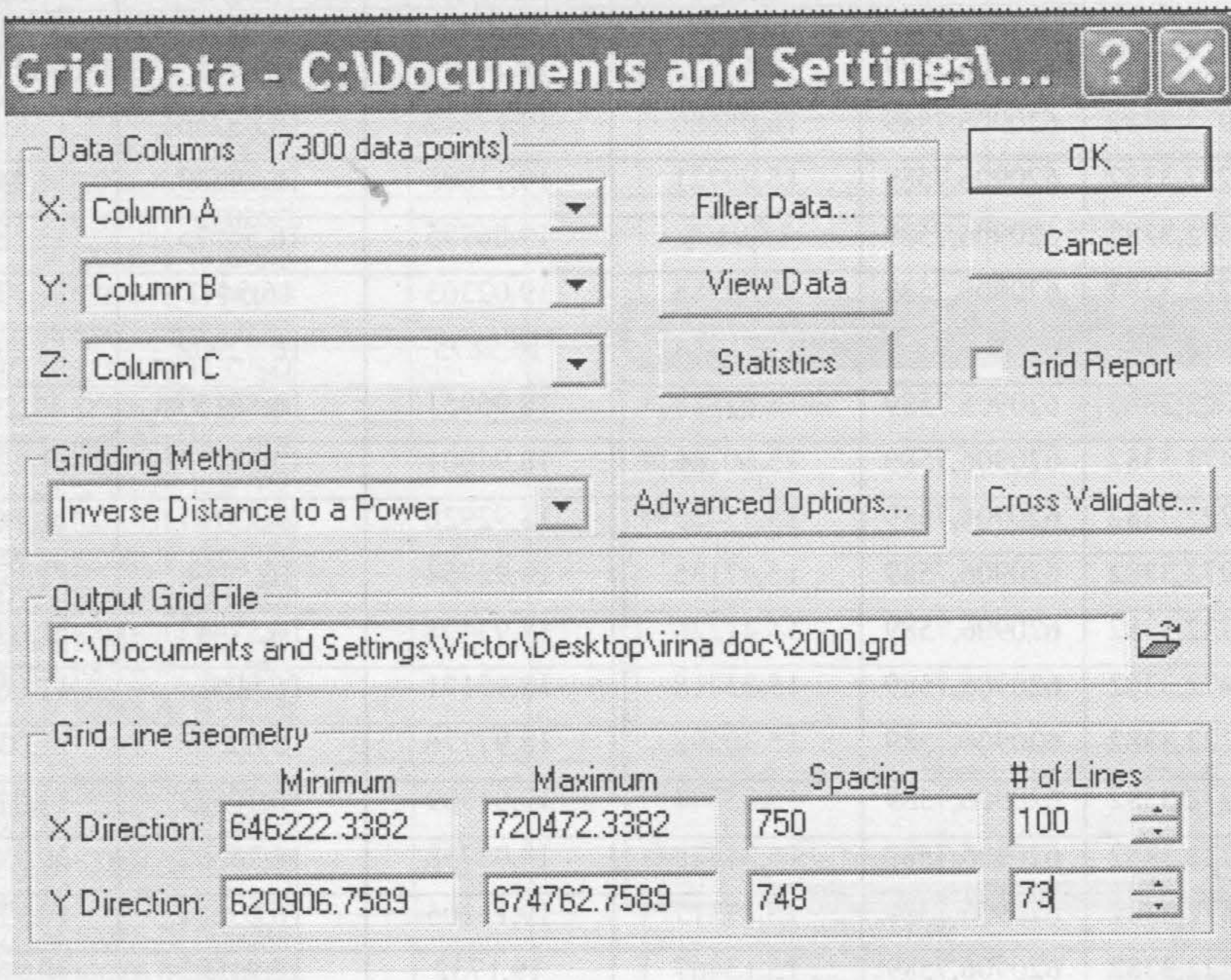


Fig. 6 – Thematic layer for the distribution of nitrate concentration in the studied territory in 2002 2004- 2D representation with isolines and 3D representation.

4. Results Obtained

Starting from the values of concentrations determined in the laboratory based on water samples from 23 drillings, after the interpolation, the concentrations are obtained in 7300 points, namely in the centre of each cell; the sizes of a cell are 750 x 748 m (Fig. 7).

Cell configuration file is view in next figure:



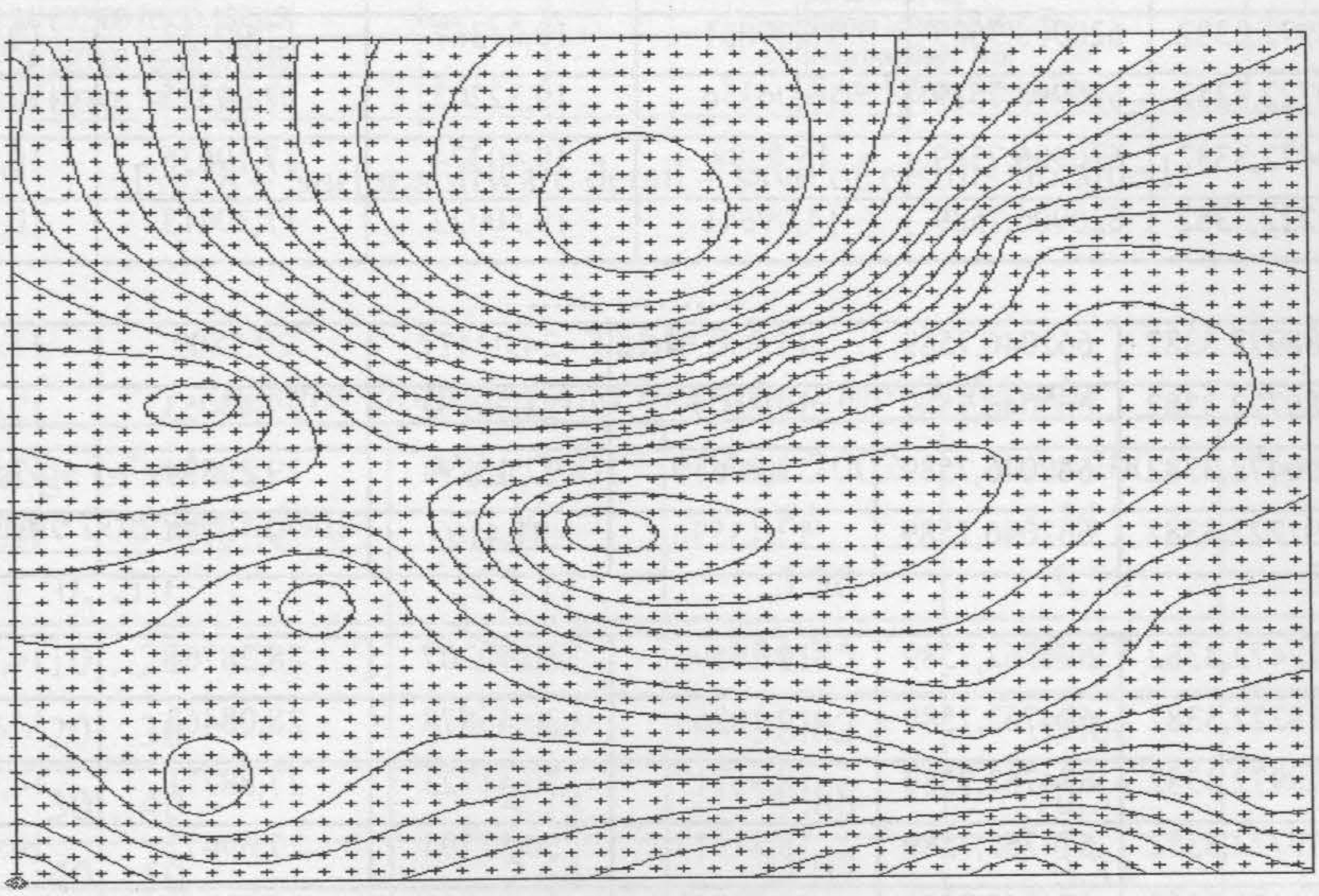


Fig. 7 – Raster points for nitrate concentration, determined by means of an interpolation method.

This table shows nitrate concentration in all raster points (located through *X* and *Y* coordinates) after interpolation, each point lying in the centre of a cell (there are 7300 cells).

Table 2

Nitrate Concentration after Interpolation

No.	X	Y	NO^{3-} Concentr. (mg/l) in 2001	NO^{3-} Concentr. (mg/l) in 2002	NO^{3-} Concentr. (mg/l) in 2003	NO^{3-} Concentr. (mg/l) in 2004
1	646222,3382	620906,7589	16,17952	19,24192	16,675	11,55797
2	646972,3382	620906,7589	16,08686	19,17712	16,63255	11,49925
3	647722,3382	620906,7589	15,99721	19,11885	16,59633	11,44293
4	648472,3382	620906,7589	15,9108	19,06755	16,56675	11,38918
5	649222,3382	620906,7589	15,82788	19,02363	16,5442	11,33817
6	649972,3382	620906,7589	15,74864	18,9875	16,52902	11,29004
7	650722,3382	620906,7589	15,67325	18,95951	16,52157	11,2449
8	651472,3382	620906,7589	15,60186	18,94001	16,52214	11,20285
9	652222,3382	620906,7589	15,53455	18,92928	16,53101	11,16396
10	652972,3382	620906,7589	15,47135	18,92754	16,5484	11,12825
11	653722,3382	620906,7589	15,41226	18,93498	16,57447	11,09571
12	654472,3382	620906,7589	15,35718	18,95171	16,60934	11,06632
13	655222,3382	620906,7589	15,30598	18,97776	16,65306	11,03997
14	655972,3382	620906,7589	15,25844	19,01309	16,70562	11,01653
15	656722,3382	620906,7589	15,21428	19,05758	16,76692	10,99584
16	657472,3382	620906,7589	15,17317	19,11105	16,83681	10,97767
17	658222,3382	620906,7589	15,13467	19,1732	16,91505	10,96175
18	658972,3382	620906,7589	15,09831	19,24367	17,00133	10,94777
19	659722,3382	620906,7589	15,06356	19,32203	17,09525	10,93539
20	660472,3382	620906,7589	15,0298	19,40774	17,19636	10,92422
21	661222,3382	620906,7589	14,99641	19,50022	17,30413	10,91383
			....			
5558	688972,3382	662046,7589	15,95078	24,04477	29,7809	13,40612
5559	689722,3382	662046,7589	14,86097	23,05962	29,45053	12,69925
5560	690472,3382	662046,7589	13,92659	22,18294	29,22894	12,08535
5561	691222,3382	662046,7589	13,13598	21,4103	29,10774	11,55761
			....			
7296	717472,3382	674762,7589	19,25596	30,50307	28,28761	14,76395
7297	718222,3382	674762,7589	19,10263	30,45878	28,08463	14,64813
7298	718972,3382	674762,7589	18,95717	30,41723	27,88771	14,53786
7299	719722,3382	674762,7589	18,81914	30,37794	27,69672	14,43284
7300	720472,3382	674762,7589	18,68811	30,34048	27,51157	14,33281

5. Interpretation of Results

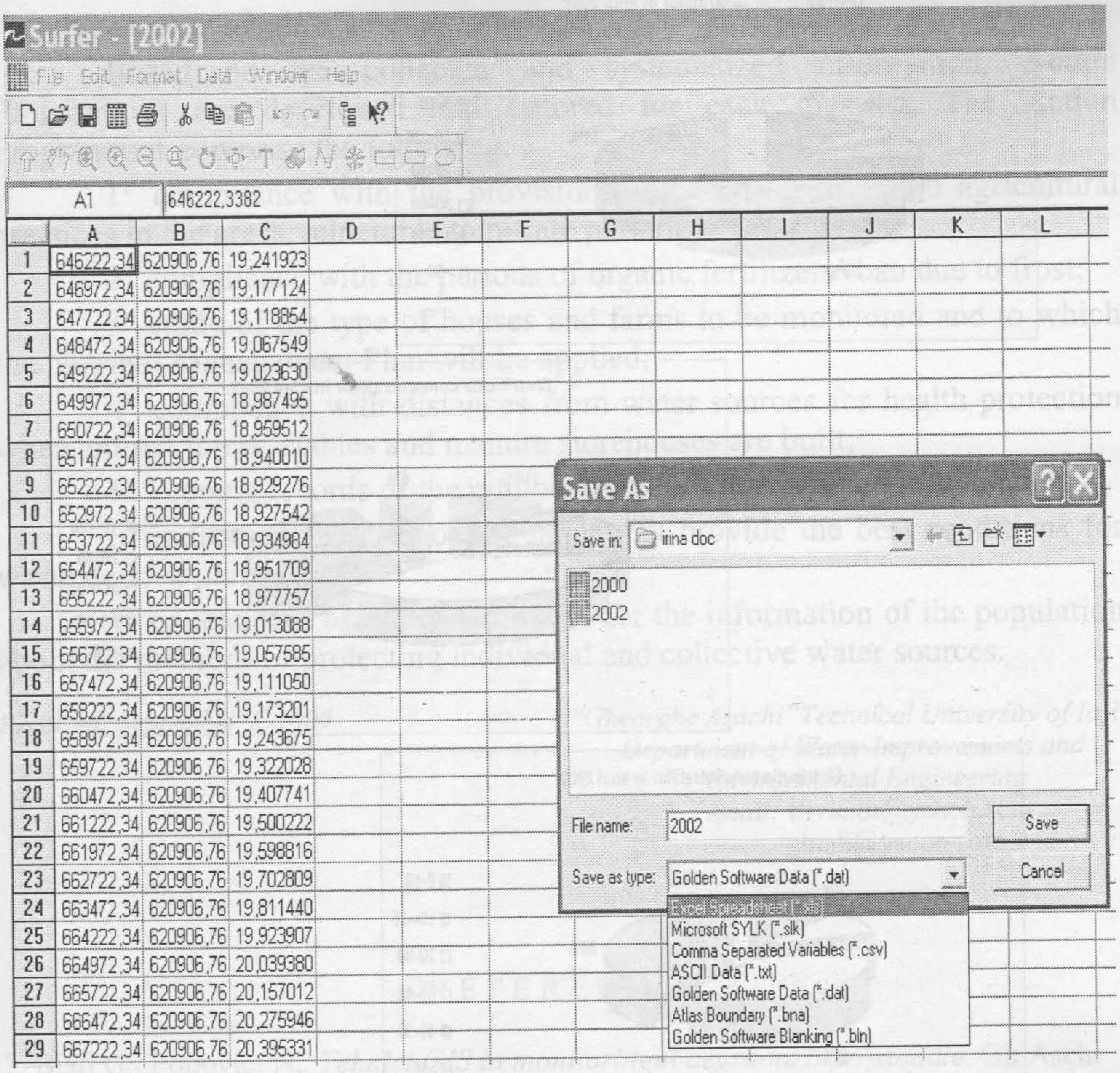


Fig. 8 – Surfer software detail – save of results obtained.

Table 3
Results Obtained And Interpretation Of Results

Range of values for nitrate concentrations	Year 2001 %	Year 2002 %	Year 2003 %	Year 2004 %
0…10	37.12	5.30	9.78	50.36
10…20	38.99	31.85	29.27	33.67
20…30	7.44	38.82	39.66	5.40
30…40	4.79	9.88	10.32	3.01
40…50	2.64	4.07	3.33	1.93
> 50	9.01	10.07	7.64	5.63

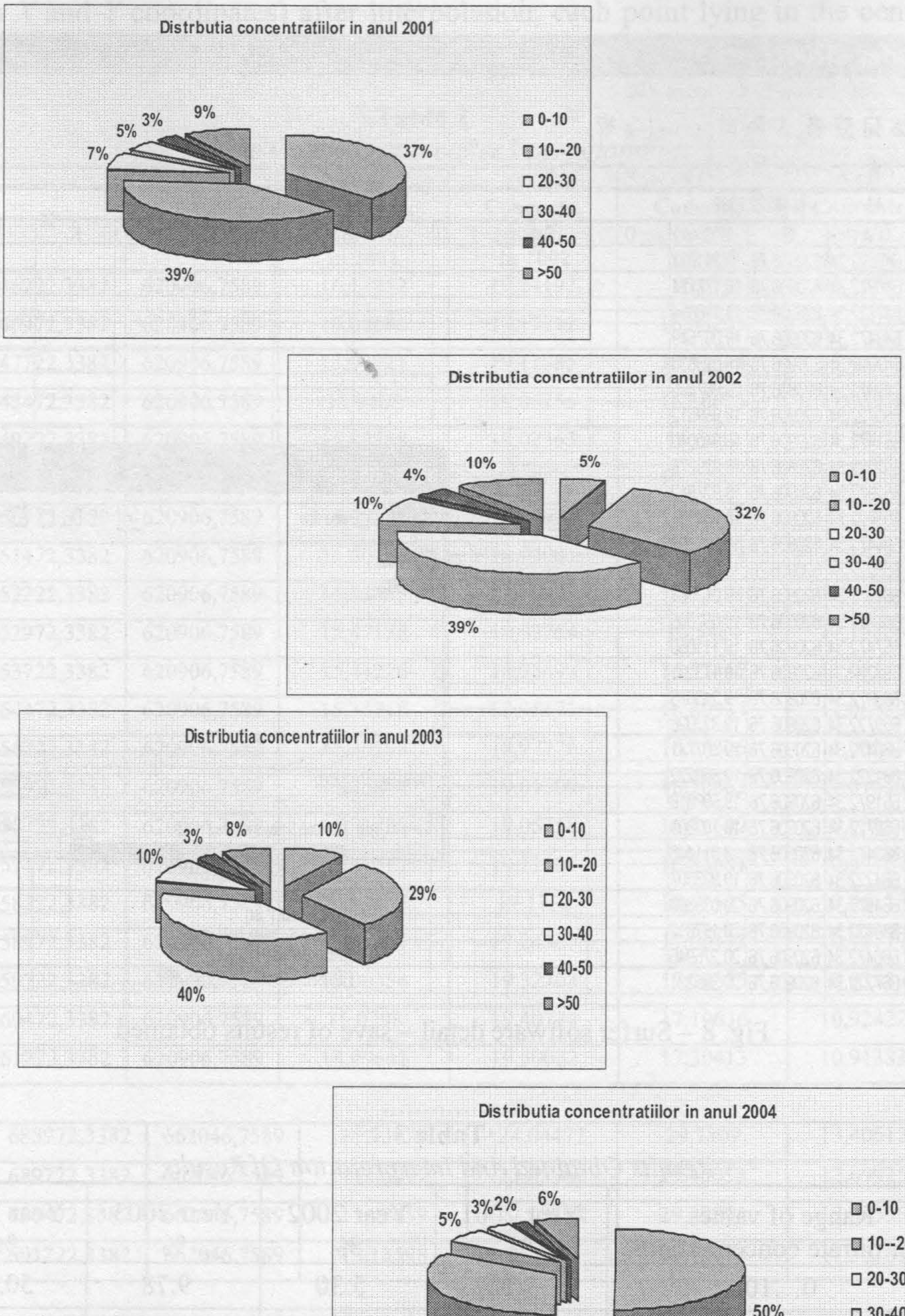


Fig. 9 – Distribution of concentrations in 2001–2004 years.

3. Conclusions

Based on the collected and systematized information, Action Programmes are developed and tailored for each location. The Action Programmes comprise the following:

1° compliance with the provisions of the Code of good agricultural practices in the areas vulnerable to nitrate pollution;

2° compliance with the periods of organic fertilizers' ban due to frost;

3° study of the type of houses and farms to be monitored and to which the Nutrient Management Plan will be applied;

4° compliance with distances from water sources for health protection when animal farms, stables and manure storehouses are built;

5° keeping records of the number of animals grazing on local pastures;

6° indicating the area of the lands that provide the best conditions for waste deposit platforms;

7° educational health programmes for the information of the population about the methods of protecting individual and collective water sources.

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STUDIUL EVOLUŢIEI CONCENTRAŢIEI DE NITRAŢI ÎN APELE SUBTERANE PE BAZA TEHNICII GIS

(Rezumat)

Poluarea solului reprezintă în procesul de evaluare/bonitare a terenurilor agricole, un factor/indicator deosebit de important mai ales atunci când sunt depăşite anumite valori ale concentraţiei ce diminuează semnificativ fertilitatea solului. Principalele metale grele care se găsesc în soluri sunt: Pb, Zn, Cu, Cd, Ni, Cr, As, Bo,

Co etc. iar printre sursele de proveniență se enumeră și depozitele de steril și reziduurile de la industria minieră.

În contextul celor de mai sus, în prezenta lucrare se fac referiri la posibilitatea evaluării spațiale și temporale cât mai exacte a acestui tip de poluare, prin crearea unui strat informațional specific poluării cu mai multe metale grele concomitent pe același teritoriu, în vederea integrării lui în pachetul de cca. 18 indicatori luați in considerare în acțiunea complexă de bonitare folosită curent în România.