PRESENT ENVIRONMENT AND SUSTAINABLE DEVELOPMENT, NR. 4, 2010

ASSESSMENT OF THE ECOLOGICAL SITUATION AND THE STATE OF THE DRINKING WATER QUALITY IN RURAL AREAS OF THE DNIESTER RIVER BASIN

Valentina Andriuca[1]

Key words: rural areas, drinking water, ecological stability, anthropic impact, animal wastes.

Abstract. This work represents an interdisciplinary study about the research of the drinking water quality opposite to the general ecological situation of the rural area, the agricultural degree of land utilization (plowing degree), the index of the ecological balance, degree of afforestation, degree of erosion, and the natural compounds of ecological stability of the territory. A special attention has been paid to the identification of the local sources of pollution of the ground waters, animal wastes, calculation of their volumes, highlighting of the dangerous chemical components that exceed maximum admissible concentrations for drinking water provided by the standards and regulations in force in Republic of Moldova. As a local object of reference the village of Lencauti, Ocnita County was investigated. The studies have shown that the quality of water from the wells is directly dependent on the anthropic sources of pollution, the volume of the animal wastes from the rural area, and is significantly influenced by the erosion degree and the general ecological stability of the grounds.

Introduction

The situation of the environment compounds has a direct influence on the population's life quality and health. The impact of the anthropic activities over the natural ecosystems causes their imbalance that may lead to irreversible changes.

The reform of all the branches in the national economy imposes the necessity of a change of attitude towards the use of natural resources, of promotion of a durable economical and social development. The research of the quality of the drinking water as a resource and a component of the environment compared to the ecological situation and factors of anthropogen impact is actual in the framework of the priorities of ecological security in the rural area. The population's health and sanitary-epidemiologic level depends on the quality and quantity of drinking water,

[1] State Agrarian University of Moldova, Chişinău, . valandriuca@yahoo.com

as well as on its permanent monitoring. To know the situation in the villages and also to explain the causes of phreatic waters pollution that undoubtedly has an emphasized anthropic and an intersystemic character is a topical subject. It is known that water quality is mainly dependent on the sources of anthropic pollution and especially on the household, animal, production waste etc. (Andries, 2005).

The purpose of the researches was to study the quality of the mine-type wells and examination of the ecological stability and instability components. A special attention was given to the sources of anthropogen impact that have pollutant effect on the waters in the wells.

1. Material and method

During the researches, the possible sources of pollution were studied and analyzed and we calculated the volumes of the created wastes and the quality of drinking water of 21 districts of Ocnita County, the rural area situated in the basin of the superior flow of the Dniester River. As a detailed subject of local reference, Lencauti village was examined; it is located on the Northern Moldova Plateau, in the forest steppe area, with predominant altitudes of 220-240 m, slightly rough nature, characterized by spread plains and hills, plateaus. Geological formations that come out are clayey Sarmatia's clays.

The index of the ecological balance, the degree of afforestation and the degree of plowing were calculated on the basis of the data of the Land Cadastre (year 2009) and they were assessed according to the approved methodology in the Republic of Moldova (Ungureanu, 1995; Andriuca, 2008, 2009).

The coefficient of the ecological stability of the landscapes is calculated as per the formula:

$$K_{ec.st} = \frac{\sum K_{li} P_i}{\sum P_i} \cdot K_r$$

Where, Kli – stability coefficient of some types of land;

Pi – the area of the land category;

Kr – coefficient of morphological stability of the relief (Kr – 1 for stable areas, Kr – 0,7 for unstable territories).

If the value of Kec.st, calculated this way, is less than 0,33, then the landscapes are considered ecologically unstable, if it is between 0,34 – 0,50 - uncertain stability, 0,51 – 0,66 – average stability and more than 0,67 – ecologically stable landscapes (Boboc N., Bejan I., 2006). According to these authors, the assessment coefficients of the ecological situation of different categories of lands were evaluated (tab. 1.)

Tab. 1 - Assessment coefficient of the ecological situation of different categories of lands

Land Category	*Coefficient of ecological stability of the territory*
Land for constructions And roads	0,00
Arable	0,14
Vineyards	0,29
Forest strips	0,38
Orchands and bushes	0,43
Gardens	0,50
Hayfields	0,62
Pasture	0,68
Lakes and natural swamp	0,79
Natural forests	1,00

Accumulation of stable waste was calculated according to the quantitative indices and the number of animals (average for 2006-2007), according to D. Davidescu, V. Davidescu, 1969, Lixandru and others, 1990, taken in accordance with the methodology of the Institute of Pedology, Agrochemistry and Soil Protection "Nicolae Dimo" (Management of organic wastes, nutrients and soil protection, 2005). The amount of stable waste accumulated in private households during one year from one animal was calculated according to table 2.

Tab. 2 - Amount of stable waste that is accumulated in private households from one animal

Species	Solid droppings, kg/day	Liquid droppings, kg/day	Total waste, kg/day	Total waste in one year (365 days), kg	Time of animals presence in the households, days/year	Waste accumulated from one animal, t/year	
						Total	Taking into account the loss of 30 %
Cattle	25	12	42	15330	270	11,3	7,9
Horses	18	5	27	9855	270	7,3	5,1
Sheep	2	0,8	3,6	1314	180	0,7	0,5
Swine	1,9	3,5	6,9	2519	365	2,5	1,8
Fowl	0,1	-	0,2	73	365	0,07	0,05

The evaluation of the ecological danger was accomplished on the bases of the system of indices that include the natural component (natural parameters of the

ecological risk), more stable group (rigid) and indices that characterize anthropic activities (more dynamic group) (Andriuca, 2009).

Sanitary-chemical parameters were investigated by the Center of Preventive Medicine, and the quality of drinking water was appreciated according to the normative in force, STAS 2874-82, used in the monitoring of drinking water.

3. The characteristics of the land fund regarding the possible influence over the quality of drinking water

For the localities in Ocnita County, we studied the areas of land resources, goods of agricultural use, the degree of the arable land, afforestation, natural and natural-anthropic ecosystems, agroecosystems that directly influence the quality of the drinking water.

The comparative analysis of the villages of Ocnita County shows significant differentiation of plowing degree that varies from 29-41% to 74-78% (tab. 3).

Data of the ecological stability coefficient attest that all locations of Ocnita County are ecologically unstable. The study of the improvement degree and of the area of eroded lands of Ocnita County (table 4) shows that soils have an average degree of improvement of 71 points, being thus a good object for agricultural use. Farmlands are characterized by a different level of erosion, maximum parameters (41%) are attributed to villages Girbova and Birnova (33,6).

4. The quality of the drinking water in Ocnita County

Quality of drinking water is a major problem for Ocnita County. In many places, the quality of the drinking water does not correspond to the norms. Analysis of the data demonstrates that there are 6301 wells and 99 springs registered, 6243 of them are arranged and 58 not arranged (year 2005). According to studies, of 397 wells examined, only 22% correspond to qualitative hygienic indexes, 78% do not correspond to the qualitative normative stipulated by the standards in force – Drinking water (tab. 3). As per analysis of the Service of Preventive Medicine, the sources of anthropic pollution are the household waste, including animal waste. It is imperatively necessary at the present moment to scientifically eloquently demonstrate the direct influence of the animal waste on the quality of drinking water, its pollution with various chemical compounds, decreasing the risk of animal waste, including the calculation of the platforms necessary for storage of the animal waste in the rural area. The rules of pollution of groundwater with nitrates, chlorides, sulfates, mineralization of some counties may be used in the prevention of other types of rural pollution – pesticides pollution, plant protection substances, active chemical elements used in the rural area, which lacks central canalization system.

In table 3, villages Birladeni with 67% of wells that do not correspond to sanitary-hygienic parameters, Calarasovca – 86%, Dingeni – 80%, Grinauti-Moldova – 85%, Lipnic – 71% and many others are emphasized.

Results show that in some places (Girbova, Dingeni, Grinauti-Moldova, Lipnic, Sauca, Verejeni, Rediul-Mare, Lencauti) the water of the wells does not correspond to the quality norms for drinking water covering about 95-100%. The situation in the villages Sauca and Grinauti-Moldova is aggravated, as more than 50% of the wells do not correspond to the requirements of microbiological parameters and they are a danger for health, they have increased concentrations of nitrates and general hardness over the limits of admissible concentrations.

3. The influence of the animal wastes' impact on the quality of drinking water

In the specialized literature, there is not enough data about the direct influence of the impact of animal waste on the quality of underground waters, especially the correlation between the number of animals and the level of direct influence through livestock. It is very difficult to find the component parts that influence the degree of water pollution, considering the fact that the sources and factors of pollution in the rural area are diverse and complex. The condition of the wells will directly depend on the animal pressing through their wastes and their leakage into the waters, on the potential of the lands' tilt and others. We have to mention that the perfect situation would be to take out the livestock of the rural areas, but this encounters at the moment many obstacles. The awareness of the alarming situation in the country side should play an important role.

That is why for the entire Ocnita District and its villages, we examined the influence of the plowing degree, afforestation , coefficient of ecological stability, and storing of animal waste in rural areas on the quality of water of the wells (table 3).

We can see in the table that Birladeni village has a very high level of pressing the animal waste (560 t/km^2), high level of plowing. 11 of 20 examined wells do not correspond to the hygienic requirements, and the water in 5 wells represents a risk for health. The same in Grinauti-Moldova, where 19 of 20 examined wells have low quality drinking water, and water of 12 wells is dangerous for consuming. The situation in Lencauti is critical, 15 of 20 examined wells do not correspond to hygienic requirements. We can clearly see in table 3 that in villages with maximum amount of animal waste, with a high quota of eroded lands and ecological instability, the situation of drinking water is

Tab. 3 - Quality of water of wells and ecological factors of influence (year 2009)

№	Locality	$G_{arable\ land}$, %	$G_{af\ afforestation}$, %	$I_{ecologic\ balance}$, %	Coefficient of ecologic stability, K	Eroded lands, %	Animal wastes		Quality of water corresponds to requirements	Do not correspond to hygienic requirements	Water is a danger for health
							total, t/year	t/km^2			
1	Bîrladeni village	**69,2**	**7,0**	**25,4**	**0,16**	8,9	**9012**	**560**	**4**	**11**	**5**
2	Calarașovca village	55,9	16,6	33,9	0,22	21,0	1206	33	6	8	6
3	Corestăuți village	75,8	4,2	23,6	0,13	9	5069	191	4	16	3
4	Dingeni village	57,0	23,3	37,7	0,20	19	**7461**	275	1	19	2
5	Grinăuți Moldova village	**68,5**	**13,9**	**26,0**	**0,16**	16	**6549**	**346**	**1**	**19**	**12**
6	Lencăuți village	64,6	11,3	28,5	0,16	18,6	3769	234	2	15	3
7	Lipnic village	**68,6**	**9,5**	**25,2**	**0,15**	29	**8292**	**249**	**1**	**19**	**6**
8	Mihălășeni village	73,8	10,6	21,1	0,14	15,6	5056	182	6	14	2
9	Ocnița village	**60,2**	**24,6**	**34,5**	**0,20**	12,1	**7482**	**228**	**6**	**14**	**4**
10	Vălcinet village	60,2	17,3	30,2	0,18	29,0	2580	107	-	18	2
11	town of Frunză	29	18,9	17,6	0,33	-	583	583	-	-	-
12	town of Ocnița	41,3	6,4	20,7	0,09	6,4	1231	-	-	-	-
13	town of Otaci	43,1	15,2	27,3	0,15	-	426	-	-	-	-
14	town of Bîrnova	69,6	11,1	22,5	0,15	33,6	6198	308	-	13	7
15	Clocușna village	**79,5**	**2,9**	**14,7**	**0,12**	22,5	**6413**	**212**	**4**	**16**	**8**
16	Gîrbova village	**51,7**	**27,5**	**43,7**	**0,23**	40,6	**6309**	**160**	-	**20**	**7**
17	Hădărăuți village	**78,1**	**4,6**	**19,5**	**0,14**	8,7	**6715**	**221**	**3**	**17**	**2**
18	Mireșeuca village	58,4	20,8	34,7	0,19	18,0	3785	235	9	9	2
19	Naslavcea village	65,7	16,2	25,9	0,33	8,4	2189	67	-	-	-
20	Sauca village	66,1	15,6	29,5	0,18	33,2	5036	188	1	8	11
21	Unguri village	67,1	11,9	23,4	0,14	24,7	1279	95	9	8	3
Total for Ocnița district		**65,5**	**13,9**	**27,3**	**0,17**	**19,3**	**96882,2**	**Averag**			

Tab. 4 - Data regarding degree of improvement and area of eroded lands in Ocnita district, (2008)

№	Name of the territorial-administrative units	Total of agricultural land (ha)	Of which pedologically examined (ha)	Average degree of improvement (points)	Eroded lands							
					Total		Including					
							Low		Moderate		Strong	
					ha	%	ha	%	ha	%	ha	%
1	Bîrladeni County	4625,38	4358	78	414	8,9	305	6,6	81	1,8	28	0,6
2	Călărașovca County	1763,40	1461	67	370	21,0	203	11,5	125	7,0	42	2,3
3	Corestăuți County	2283,67	2009	75	207	9	185	8,1	13	0,56	9	0,3
4	Dingeni County	2374,42	2129	73	451	19	219	9,2	164	6,9	68	2,9
5	Grinăuți- Moldova County	2956,72	2616	78	472	16	324	11,0	119	4,0	29	1,0
6	Lencăuți County	2508,64	2342	70	468	18,6	360	14,3	83	3,3	25	1,0
7	Lipnic County	3005,3	2309	63	869	29	544	18,1	286	9,5	39	1,3
8	Mihălășeni County	2454,,5	2185	75	383	15,6	312	12,7	63	2,6	8	0,3
9	Ocnița County	3277,6	3001	76	398	12,1	284	8,7	95	2,9	19	0,6
10	Vălcinet County	2229,4	2010	78	645	29,0	346	15,5	238	10,6	61	2,7
11	town of Frunză	126,23	2	57	-	-	-	-	-	-	-	-
12	town of Ocnița	278,22	66	59	18	6,4	18	6,4	-	-	-	-
13	Town of Otaci	322,2	154	78	-	-	-	-	-	-	-	-
14	Bîrnova village	2667,8	2542	66	897	33,6	641	24	219	8,2	37	1,4
15	Clocușna village	2828,3	2496	63	637	22,5	538	19	99	3,5	-	-
16	Gîrbova village	1788,6	1559	63	727	40,6	417	23,3	291	16,2	19	1,1
17	Hădărăuți village	2730,0	2373	67	237	8,7	156	5,7	63	2,3	18	0,7
18	Mireșeuca village	1433,0	1222	68	258	18,0	221	15,4	37	2,6	0	-
19	Naslavcea village	2103,9	1883	80	176	8,4	168	8,0	8	0,4	-	-
20	Sauca village	2612,3	2216	65	866	33,2	527	20,2	218	8,3	121	4,6
21	Unguri village	1528,0	1268	62	377	24,7	283	18,5	62	4,1	32	2,1
TOTAL		**45897,52**	**40201**	**71**	**8870**	**19,3**	**6051**	**13,2**	**2264**	**4,9**	**555**	**1,2**

Tab. 5 - Chemical compounds of water of the wells in Lencauti, Ocnita District

№ source of water	Quality indixes													
	Turbidity	Nitrites, mg/l	Nitrates, mg/l	Residue sec, mg/l	Sulphates, mg/l	Chlorides, mg/l	Total hardness, me/l	Ca^{2+}, mg/l	Mg^{2+}mg/l	Na+K	Mineralization, g	F, mg/l	Coliformis total	Wastes on well's area, t/year
034 (graveyard)	1,08	< 0,003	57	807	54	38	10,5	103	64	120	1,1701	0,98	-	-
001	1,21	< 0,003	60	512	52	45	8,0	122	23	33	0,7021	1,01	-	0,7
083	0,96	< 0,003	150	2208	823	162	36,0	470	152	64	2,7006	1,28	-	26,5
058	1,21	< 0,003	117	914	126	50	16,0	140	109	24	1,2380	1,07	-	54,6
018 (church)	1,08	0,002	193	967	197	148	17,1	124	133	12	1,1848	1,04	-	-
061	1,0	< 0,003	70	924	99	61	18,0	104	156	18	1,3508	0,96	-	47,3
059	1,21	< 0,003	87	724	40	78	10,3	104	62	73	0,9807	0,75	-	33,0
069	1,33	< 0,003	243	999	60	141	16,7	160	106	23	1,2523	1,08	-	7,5
057	0,96	0,007	269	1182	164	157	18,3	162	124	52	1,4297	0,77	-	31,5
109	1,08	< 0,003	121	837	59	49	12,0	136	66	67	1,1122	1,1	-	11,9
031	1,21	< 0,003	472	2766	830	136	40,0	621	109	118	3,2625	1,25	-	31,2
064	1,33	< 0,003	120	927	199	61	15,9	102	131	32	1,2192	1,02	+	13,0
070	1,33	< 0,003	248	1053	137	140	18,1	132	140	30	1,3447	1,07	+	23,9
CMA	1,5	< 0,003	45	1000	500	350	8,0	100	80	200	1,000	1,2	-	-

catastrophically dangerous for health. Probably the mineral fertilizers used on the farming lands also increase the number of pollutants that get into water.

In Girbova, the degree of arable lands represents 52%, the index of ecologic equilibrium represents 44%, the coefficient of ecologic stability is of 0,23 and the eroded lands – 41%. These are favorable conditions for 6309 t/year animal waste to get into waters, which explains the 100% ration of the district wells that do not correspond to hygienic conditions, and in 7 wells water represents a serious danger for health. The wells are polluted with nitrates, calcium, magnesium and others (tab. 5).

The mathematical-statistical analysis shows a high correlation between the degree of agricultural use of land and the low quality of drinking water (R=0,63).

Tab. 6 - Comparative parameters of the quality of drinking water, Râşcani, Moşeni (2010)

Indicator	Well with impact	Drinking water without impact (Vartic)	CMA
1	2	3	4
Fixed residue, mg/dm^3	806	644	1000
Calcium, mg/dm^3	98	-	100
Magnezium, mg/dm^3	43,8	-	80
Sodium, mg/dm^3	103,8	53,0	-
Hydrocarbons, mg/dm^3	490,4	570,2	Unlimited
Sulphates, mg/dm^3	123,8	61,4	500
Chlorides, mg/dm^3	61,9	31,0	350
Nitrates, mg/dm^3	82,5	48,4	45
Nitrites, mg/dm^3	0	-	0
Ammonium, mg/dm^3	0	-	0,05
Phosphates, mg/dm^3	0	-	0,1
Flourides, mg/dm^3	0,12	-	1,5
Hardness, me/dm^3	9,2	9,0	8,0
pH	7,8	-	6,5-8,5

The ecological danger for Lencauti, Ocnita District was measured according to a special methodology (Andriuca, 2009). Results show a critical level of the anthropogen impact on the agro-landscapes. In 2010 (May), in Lencauti, Ocnita District 13 wells were examined where the chemical quality of underground water was known. Researches meant to find out the annual quantities of wastes that accumulate around wells' perimeter. Results are shown in table 5. Data show that there are wells where a large amount of animal wastes accumulate annually. In

table 5, we can see that only in 2 of 13 wells (F/p nr 001 and F/p nr 069) the quantity does not exceed 1 t/year. Most of the wells have an impact of 20-30 t/year, but there are also water sources where more than 40 t/year of animal wastes accumulate (F/p nr 061 and F/p nr 058) in the zone of well's strict protection (50m).

Comparative analysis of the lab chemical data of the quality of wells water of Lencauti and the amount of animal wastes of the perimeter of protection show that the rural impact through wastes significantly affects the level of pollution of water with nitrates. In all examined wells, the content of nitrates exceeds CMA (45 mg/l). In 10 of 13 examined wells, the level of NO_3 is 2-9 CMA. Seeing the table, we may conclude that wells have a very high nitrate pollution level (>200mg/l). The chemical analysis of the waters shows that in two wells (F/p nr 083 and F/p nr 03) CMA for sulfates (CMA = 500 mg/l) is exceeded, reaching high concentrations of 823 and 829 mg/l.

In all researched wells, water has an increased hardness, except one well (F/p nr 001), which is situated on a slope and possibly may have a good lateral leakage. In the rest of the wells, the hardness of water exceeds CMA (10 me/l) 3 to 4 times.

Table 6 confirms the negative influence of the impact of animal wastes over the quality of drinking water; the table represents two sources of drinking water, one with impact of wastes and another without rural impact, situated at 1,5 km outside the village (area Vartic, Moseni village). The studied objects are located in Rascani District, Moseni village, within Northern Moldova Plateau.

Conclusions

During this research, the possible sources of water pollution in 22 rural locations of Ocnita District were studied and analyzed.

The situation of the land fund of the district is characterized by a high level of plowing degree, and the degree of afforestation is average and low.

According to the coefficient of ecological stability, all the examined locations are unstable.

Annual quantity of animal wastes in year 2009 – 96882 t or 202 t/km2. Maximum pressing was discovered in Barladeni – 560 t/km2.

The results of the study show that natural conditions and lands' degree of erosion significantly influence the ecological situation of the regions.

The quality of water of 20 wells of each examined village does not correspond to hygienic conditions. Chemical analysis of water shows that in most wells we traced excesses of CMA according to the following indices like: nitrates, mineralization, hardness, dry residue, magnesium, calcium etc.

As a detailed reference object, we examined the Lencauti village that has as a major ecological problem the quality of the drinking water, formation of animal wastes, their placement, non authorized dumps, and sanitary level of some lands.

The level of the anthropogen impact on the agro landscapes in Lencauti is critical, the ecological risk is 1,368.

Analysis of the data shows that the drinking water of Lencauti, Ocnita District has low quality, seriously affected by the impact of animal wastes of the private sector.

Comparative results of the chemical analysis of laboratory of water quality of wells of Lencauti and animal wastes of the protection perimeter show that rural impact through wastes does significantly influence the pollution degree of waters with nitrates, fluorine, sulphates, calcium, magnesium.

In all examined wells of Lencauti, water has an increased hardness, except a well (F/p nr 001), which is placed on the slope and possibly may have a developed lateral leakage. In the rest of the wells, the hardness of water exceeds CMA (10 me/l) 3-4 times.

There is an urgent necessity to find alternative sources of drinking water in the researched location.

Among the easy ways of protection, we recommend cleaning of wells, monitoring of water quality and avoiding the sources of pollution.

It is necessary to minimize the anthropogen impact, to create protection zones for waters and to permanently monitor their quality, including informing the community, taking the decision not to use water of some wells until the quality of water will not be improved.

One of the efficient methods of minimizing the impact of animal wastes from around Ocnita District would be to deposit animal droppings on special platforms and their centralized evacuation.

The most affected villages that need urgent intervention in this matter are the villages of Barladeni, Lipnic, Dingeni, Ocnita, Lencauti etc.

Bibliography:

Andrieş, S. (2005), *Managementul deşeurilor organice, nutrienţilor şi protecţia solului*. Chişinău. p. 42-43.

Andriuca, Valentina (2009), *The ecological state's evaluation and the reducing of the anthropogenic impact in the rural area*. In: Present environment and Sustainable Development. vol. 3. Iaşi. p. 55- 64

Andriucă, Valentina (2006), *Problemele de mediu şi utilizarea raţională a resurselor naturale în localităţile rurale.* „Eu şi Dunărea". Chişinău. p. 59.Andriuca, Valentina (2006), Evaluarea situaţiei ecologice a teritoriului. „Starea actuală, problemele utilizării şi protejării solurilor". Lucrările conferinţei ştiinţifico-practice. Chisinau p. 127-130.

Boboc N., Bejan I (2006), *Considerații privind evaluarea gradului de stabilitate ecologică a peisajelor din Republica Moldova*. „Ecologie şi protecția mediului – cercetare, implementare, management". Materialele Conferinței Jubiliare – INECO 15 ani. Chişinău, p. 4 – 7.

Cadastru funciar al RM la 1 ianuarie 2009. Chişinău, 2009. 986 p.

Sandu, Maria. (2006), Apa în natură. In: *Eu şi Dunărea*. Chişinău. p. 5-18