University of Groningen

WECF - Women in Europe for a Common Future

Drinking water quality in Gârla Mare, (Romania)

Anna Samwel

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Haren

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Preface

I am a 4th year biology student of the Rijks Universiteit Groningen. I did a seven weeks practical (2nd November-19 December 2003) for the Non Governmental Organisation Woman in Europe for a Common Future (WECF) in the village Gârla Mare (Mehedinti district, Romania) for the pilot project 'Safe Drinking Water'. Attie Bos from the Science Shop for Biology supervised my practical.
The pilot project 'Safe Drinking Water' is in implemented in cooperation with NGO "Medium et Sanitas" (M&S), Bucharest, Romania.
The local NGO workers in Gârla Mare were Alina until October 2003, and during the practical Angela Boiangiu and Adriana Balasoiu in double leadership, chosen by an open interview by Riti Herman-Mostert from WECF.
Gârla Mare was chosen by good connections between M&S (Ioana Jacob) and the doctors Vladulescu.
Financial support: Ministry of Foreign Affairs, The Netherlands; MATRA Project "Safe Drinking Water, a catalyser for citizens participation".
Term: October 2001- 15 February 2004.
The aim of the project by WECF is to improve the situation of the people of Gârla Mare concerning water quality and sanitation and to foster public participation and democracy building for the long term.

Romanian politics focuses and invests very little on rural development, though these areas are still backward and people live under primitive conditions. The problems are poorly documented. Donor countries have been giving little sustainable development aid for rural areas. This research will document the situation regarding to drinking water quality in a Romanian village and focus on an attempt to improve the situation.

Fig. 1. Map of Romania and Mehedinti district (www.rotravel.com)

Summary

In the Romanian village Gârla Mare relies on well water for drinking. The water is polluted with micro-organisms and nitrate due to the pit-latrines which are used for sanitation. This is a potential risk for small babies and pregnant women to get ill from baby blue disease and diseases can be spread due to the microbial contamination of the water.
This research attempts to investigates the causes of variating nitrate pollution of the wells. The common and private wells and several springs were measured for nitrate. For the wells the depth, water table, the state of the wall and cement and the presence of a cover were determined. It turned out that the quality of cement around a well and the presents of a cover at common wells reduce nitrate contamination significantly. Deeper private wells are significantly more contaminated with nitrate.
To improve the situation for the villagers in means of water quality and sanitation, the NGO's WECF (Women in Europe for a Common Future) and M&S (Medium et Sanitas) started the pilot project 'Safe drinking water, a catalist for citizens participation'. Water samples were measured. In the two schools and dispensary washing basins and filters for safe water were installed. In one of the schools ecosan toilets were installed, which compost human waste and therefore prevents groundwater pollution.
In the project the whole village should participate. Due to the lack of a good framework, technikal knowledge, and good communication goals were only partly reached. Villegers have other, more urgent problems than water quality. The lokal conditions makes it difficult to improve water quality for the development worker. Therefore, socio-economic improvements are nescesary for sustainable development.

Acknowledgements

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I want to thank all the wonderful people from Gârla Mare, which made my stay unique. I want especialy thank my guest families, Angela, Polie and Mirella Boiangiu, and Zamir and Penelope and their three great boys for the hospitality and giving me insight in their lives. I want to thank Angela Boiangiu and Adriana Balasoiu for their help and company, and all the energy they invested in the project. Even as the women from the women group for all their enthusiasm and patience. I want to thank the workers who did their task as well as they could, and all the other people who were a great help in finishing the construction. Finaly I want to thank Riti Herman-Mosterd for the good company and all the things I learned from her.

Introduction

1.1 Rural areas and drinking water
In the WHO European region, 120 million people do not have access to safe drinking water, and even more have no access to sanitation. In Romania, only 63% of the population is connected to a central drinking water distribution system. 55% of the population live in rural areas (World Bank 2003).
In rural areas not connected to a sewage system, latrines with holes in the ground (pit latrines) are commonly used. This is known to result in pollution of the groundwater with nitrate and faecal bacteria.
In intensively used agricultural areas nitrate from fertilisers and pesticides tend to reach the groundwater. Often the wells used for drinking water are not deep enough to reach beyond the polluted groundwater. Problems with drinking water quality are widely spread.

1.2 Example village Gârla Mare
Gârla Mare can act as an example village for many rural areas in Eastern Europe, the Caucasus and central Asia (CEE and NIS countries). There occur similar problems with drinking water and sanitation.
Gârla Mare is located in the south west of Romania, on the flanks of the Danube near the frontage to Bulgaria and Serbia. The nearest city is Turnu Severin (Mehedinti district). (see fig.1). The climate is continental, hot dry summers and wet cold winters.
There live ca 3500 inhabitants in ca 1200 families. The main income source is agriculture, with the main crop being corn. Landowners are mostly self-sustaining and the farms vary in size from 0.5 to about 10 hectare. Most people grow some vegetables and have for example a pig, some sheep and poultry. Ca 25% of the population is Roma and mostly landless. A part of them travel to other countries to earn some money. Unemployment and poverty is one of the biggest problems in the village (WECF, 2002).
In the village is electricity, a satellite connection, some small shops, a weekly marked, two schools (class 1-4 and class 5-8), a kindergarten and a dispensary with two doctor practices. No central water supply or sewage system is available. The latrines are holes in the ground with a wooden 'hut' on top (see fig. 3). If the hole is full it will be covered with earth and the hut is placed on a new hole. The domestic wastewater is poured in the garden on the ground.
This situation in Romania, focused on Gârla Mare, gives rise to the main question of this research.

What are the problems regarding to drinking water quality in Gârla Mare and how can they be solved?

Secondary questions:
-How is the water supply organised?
-How do pollutants reach the groundwater?
-What is the water quality, i.e. what kind of pollutants are found and how much?
-What is the state of the wells, i.e. depth, state of wall around the wells, coverage?
-What is the cause of differences in pollution levels between wells?
-What health risks do these pollutants present?
-What has been proposed to improve the water quality?
-Which difficulties are met in regard to sustainable development?

2. Background information on groundwater pollution in rural areas

In rural areas with no central water supply, drinking water is mostly obtained from groundwater. To reach the groundwater, wells are drilled.
Where there is no central sewage system, pit latrines are used for sanitation. This is known to result in nitrate pollution and microorganism contamination of the groundwater. (Cave, 1999)
This study is mainly concentrated on nitrate pollution.

2.1 Water supply

In Gârla Mare about 43 common wells and about 400 private wells are present, with a depth of 16-28m. The water is withdrawn with a bucket at a chain, pulled up by a wheel (wind wheel bucked), or with a chain with a bucked at each end. Some people have a pump, sometimes connected to a reservoir for running water. Most people have a private well in their garden, the others use the common wells or the wells of their neighbours. Common wells are diged manual and have a diameter of one meter, the private wells have mostly a diameter of about 30 centimetres and are drilled.
Throughout the village several dry or too dirty wells are out of work.
Beyond the borders of the village exist several springs, which spring at the base of the superior Danube terrace and flow into a cement tub. The biggest spring is called Sipot and water flow at 20 l/sec.
Most people use the well water for drinking and domestic needs. They may use different wells for domestic needs and for drinking, because not all the wells have clean water. The springs are used to rinse the washings and intestines of slaughtered bigger animals because there is more water easy available.

2.2 Groundwater

The groundwater is in the saturated layer in the ground, were all pores (the spaces between the soil particles), are filled with water. The top of this zone is called the water table. The layer above the saturated layer is the unsaturated layer, were the pores are at least partly filled with air. The wells are holes in the ground, which reach beyond the water table in the saturated zone and are filled with groundwater (see picture). The saturated zone is called an aquifer if it has the capacity to fill wells and water can be drawn out.
The groundwater is recharged by rainwater. Pollutants reach the groundwater by leaching. The rate in which recharge and leaching take place depends on several factors, like soil type and quantity of rainwater (Lamond, 1999).

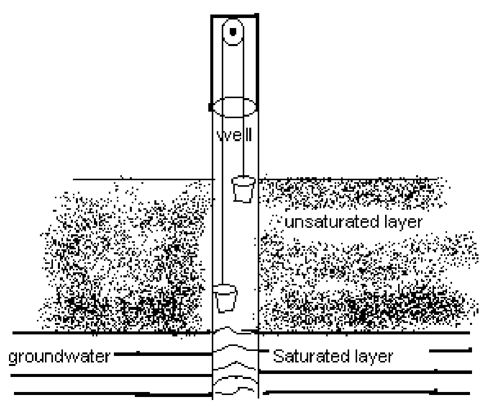

Fig. 2.
Schematic well

2.3 Nitrogen

Human waste is released in the ground under pit latrines. Human and animal waste contains nitrogen in the form of urea and other organic forms (Chapman, 1992). 95% of the nitrogen in human waste is found in the urine, mostly in the form of urea (Jacks, 1999). Urea ((NH2)2CO) is readily converted to ammonium (NH_3) by micro-organisms.
Under aerobic conditions, ammonium is oxidised to nitrate (NO_3^-) (nitrification), oxygen is used as electron acceptor. This happens in two steps by two different bacteria. ammonium is oxidised to nitrite (NO_2^-), and nitrite is oxidised to nitrate. Nitrate and nitrite are both very soluble in water (Madigan, 2000).

Denitrification takes place under anaerobic conditions where nitrate is used as an electron acceptor. Nitrate is reduced by bacteria first to nitrite, which is readily reduced to the gasses nitrous oxide (N_2O) and nitrogen gas (N_2). The gasses disappear in the atmosphere (Madigan, 2000).
Parkin (1990) found a significant correlation between soil water and denitrification. So the more water in the soil, the more denitrification well take place. Oxygen enters the soil by diffusion. The diffusion is greater in bigger pores than in smaller pores. Oxygen diffuses only very slowly in water. More diffusion of oxygen will take place in sandy soils with big pores than in clay soils, with small pores (Smith, 1990).
Both the rate of nitrification and denitrification depend on several factors, like the type of soil, water content of the soil, oxygen, organic carbon etc., but the rate in which this factors influence the processes is not yet quantified.

2.4 Factors of influence on pollution

In literature several factors are mentioned which can be of influence on groundwater pollution. Institutions make recommendations about treating wells. Here are listed several factors which can have influence on well water quality and is explained how they have influence especially in regard to nitrate pollution.

- The presents of latrines. Arnade (1999) found a significant correlation between an increasing concentration of faecal coliform, nitrate and phosphates concentrations, and decreasing distance between wells and septic tanks. Septic tanks pollute the groundwater in a similar way as latrines. Authorities recommend a minimum distance of well to pollution sources. Pollutants like animal feeding facilities and sanitary landfills shouldn't be within 50 to 350 meters. (Jackson, 2001) In Gârla Mare this is not realisable, because the houses are close to each other and the yards are small. The strongest effect of pollutants will be within 20 m around the well.
- Direction (upstream or downstream) of pollution sources in relation to the well. Water in aquifers flows downhill. So if the source of pollution is situated upstream from the well its contaminating effect will be greater than when situated downstream.
- The depth of the well and water table. The deeper the aquifer, the more time the polluted water has to trickle down to the well. During transport through soil, micro-organisms can be eliminated. Soil is known to have a filter function for both nitrate and micro-organisms. Authorities recommend a minimum distance between the bottom of the latrine and the water table (Jackson, 2001). On the other hand, in the unsaturated (aerobic) zone, ammonia can be converted to nitrate. So the longer the stay in the unsaturated zone, the more nitrate can be produced (Parkin, 1990).
- Other pollutants like animals and waste storage around the well. All animals have faecal bacteria and nitrogen in their excrements, which can be a source of pollution. Animals can be kept away from wells by guards.
- The state of the cement around the well. It should not let water through.
- The coverage of the well, to protect it from organic contamination entering from above.
- State of the wall around the well. It should be in a good state and well sealed. If run-off surface water can run into the well the water quality will suffer. The run-off surface water can contain all kinds of pollutants like animal faeces and other waste.
- The kind of soil. The microbiology and the chemical and physical properties differ between soils, which may have influence on the filter function and denitrification and nitrification rates. In soils with bigger spaces between the soil particles the water flows more rapid and the pollutants reach more rapid the groundwater (Jackson, 2001).
- Temperature influences the microbiological activity, which influences nitrification and denitrification. (Madigan)

Fig.3 A typical pit latrine in a yard. (Samwel, 2003)

3. Health risks

Before presenting the results of my research, here are listed some of the pollutants occurring in Gârla Mare and their impact on health. This research concentrates on nitrate because it is easy and cheap to measure.

3.1. Nitrate

High nitrate levels in drinking water are linked to 'blue baby syndrome' or acute infantile methaemoglobinaemia, cancer and hypertrophy of the thyroid.
Between 1985 and 1996, 2913 cases of blue baby syndrome were recorded in Romania's rural areas, of which 102 were fatal (WHO, 2002).
Nitrate (NO_3^-) itself is not a threat to health, however, nitrate is readily reduced to nitrite (NO_2^-), which causes blue baby syndrome.
Bottle-fed babies in areas where nitrate content in drinking water is high are particular at risk. Baby stomachs are not sufficiently acidic to inhibit the microbial conversion of nitrate to nitrite. Foetal haemoglobin, which still persists in the baby blood, has a higher affinity to nitrite ligants than normal (adult) haemoglobin. The nitrite formed in the stomach comes readily into the blood where it binds to foetal haemoglobin, and prevents it to bind to oxygen. The baby gets insufficient oxygen and gets 'blue'. Fortunately it can be treated and is rarely lethal. Also pregnant women are at risk. Microbial pollution combined with nitrate pollution of water seems to enlarge the risk of baby blue syndrome (Hardmann, 1993). The harmful dose of nitrate differs from case to case and depends on many factors such as acidity of the stomach and the presence of diarrhoea.
Under acid conditions nitrite readily reacts to several components of food in the stomach. Some of these N-nitroso products formed are known to be carcinogenic to a wide range of animals. Though there appears no clear epidemiological evidence to link the nitrate content of drinking water to the incidence of stomach cancers. Studies are complicated because drinking water often is not the main course of nitrate intake (Hardmann, 1993).
High nitrate levels cause a decreased intake of iodine by the theriod glands. The iodine ions are in competition with the nitrate iodine for intake. This effect is stronger when nitrate is abundand and iodine is sparse.
The maximum limit of nitrate in drinking water, set by the EU and recommended by the WHO is 50 mg/l. This standard is set to ensure that drinking water will not cause methaemoglobinaemia at the vulnarable group, young babies with diarhoea.

3.2 Micro-organisms

Micro-organisms can be the cause of all kinds of water borne diseases. They are caused by the ingestion of water contaminated by human or animal faeces or urine containing pathogenic bacteria, protozoa's or viruses, including cholera, typhoid, hepatitis A, amoebic and bacillary dysentery and other diarrhoea. In the period of 1986 -1996, the following outbreaks of water-borne diseases were reported in Romania; bacterial dysentery, Gastro-enteritis, hepatitis A, cholera, typhoid fever, methaemoglobinaemia (WHO, 2002).
Pathogenic organisms in faeces are sometimes present, but not necessarily. It depends on whether the human or animal, which produces the faeces, is contaminated.
Escherichia Coli and faecal streptococci are always present in high numbers in faeces and are found exclusively in faeces. They are used as indicator organisms for faeces. Pathogenic organisms are only present in small numbers and difficult to identify. If the indicator organisms are present in water, it is (almost) sure it is contaminated by faeces, which may contain pathogenic organisms as well.
Vermitech (US EPA, 1992) states that faecal coliform survive in sludge enriched soil on average 2 months and for as long as a year. Cool, wet, nutrient rich conditions are favoured. They are not able to reproduce in the soil or in water.
The EU limit and WHO recommendations for drinking water are zero for faecal coli and faecal streptococci.

3.3 Atrazine

Atrazine is a herbicide used in corn growing. It is well soluble in water. Under natural conditions there have been seen half-life times of 20 -50 days, but it can be fairly stable in groundwater. It is considered as a hormone disrupter and carcinogenic (WHO, 2000). In Germany it is forbidden since 1991 because of massive groundwater pollution.
The maximum limit of atrazine, set by the EU and recommended by the WHO is 100 Ng/l.

4. Research and Data

4.1 Measurements taken by WECF

To investigate the pollution of the groundwater in Gârla Mare, WECF took some measurements. 70 Wells were tested for nitrate, 12 on bacterial contamination and 3 on pesticides.
The 70 wells were tested with nitrate test strips from Merck. Nitrate concentrations ranging from 40 mg/l up to more than 500 mg/l were found. The mean concentration was 120 mg/l.
The wells with nitrate concentrations with less than 50 mg/l were tested for faecal streptococci, *escherichia coli* and coliform bacteria. Faecal coli's were found 130 to 918 counts/100 ml and faecal streptococci 13 to 2400 counts/100 ml. In the wells at the two schools respectively 1720 and 224 faecal coli/100 ml and 5420 and 3480 faecal streptococci/100 ml were found.
Three wells were tested for pesticides. Atrazine was found in concentrations of 135 to 165 ng/l. No other pesticides were found above the maximum EU limit.
In the Sipot spring was found 60 mg/l nitrate and 360 to 500 ng/l atrazine. There occurred from time to time coliform bacteria (WECF, 2002, 2003) (For more details see www.wecf.org).

4.2 Materials and method own research

The nitrate concentrations measured in well water by WECF, showed great variance. The variance was without a clear pattern, it was not clear why a certain well was more polluted than another.
Taking into account the factors mentioned in section 2.4, an attempt was made to find out the cause of the big differences in nitrate concentration within the wells.
39 communal wells were numbered and marked on a map of the village. The existing map had to be verified and corrected.
During the research 15 private wells were examined at random and marked on the map.
Four springs were marked on the map.
The depth and water table from each well were measured by a plumb-line. The line was marked every meter. When the lead hit the water, a splash was heard and the water table was determined by counting the marks on the line. The centimetres were estimated.
The same procedure was followed by determining the depth of the well. The lead lost its weight when it hit the ground and the depth could be determined. The ground level was taken as zero.
The water layer is well depth minus water table.
The state of the wall was noted. Three categories were used; 1 - a bad state, with a lot of deep cracks. 2 – intermediate state, with some smaller cracks. 3 - a good state, with (almost) no cracks. The region from above ground until about 1,5 meter under ground could be investigated.
The state of the cement around the well was noted. Four categories were used; 0 - no cement at all. 1 - a bad state, the ground only partly covered with cement. 2 - intermediate, with cracks in the cement. 3 - a good state, with (almost) no cracks.
The state of the well is the state of the cement plus the state of the wall.
The presence of a roof, a cover and/or a guard was noted.
The nitrate content of the wells and springs was measured with nitrate test strips from Merck. At the spot the test strip was held one second in a water sample. The superfluous water on the strip was swiped of. After one minute the nitrate content was visible by comparing the colour of the test strip to the standard. The values visible on the standard were 10, 25, 50, 100, 250 and 500 mg/l.
If possible, the clearness of the water was determined by the bare eye.
Other remarks, obtained when questioning people at the spot, were noted.
When all the wells were tested, it was found out that the nitrate tests had to be taken at a temperature over 10°C. On most of the sampling days the temperature was below 10°C.
Samples from 15 wells and 1 spring were measured again inside at room temperature to determine the error.
The nitrate values found at the spot were used for the calculations.
A regression was made using Excel and SPSS between nitrate contents, depth, water table, water layer, state of the wall, state of cement, general state and presence of a cover.
Communal wells and private wells were calculated separately.
The means of all values of the common and private wells were compared, as well as the means of all values of wells with a nitrate content of 50 and >50 mg/l with an Independent-Samples T-test in SPSS.
Where needed the nitrate values were re-written in real numbers; <25 was written as 20, >25 as 30, <50 as 40, >50 as 60, <100 as 80, >100 as 150, <250 as 200.

The nitrate values, well depth and water table were divided in categories and marked on a map indicated by colours.

Fig. 4. Nitrate testing on the spot with test strips. (WECF, 2003).

4.3 Results

See appendix 1 for crude data. The average nitrate content is 59 mg/l, the average depth 18,53 m, the average water table 17.48 m, and the average water layer is 1.06 m.
The results of the regressions of private and common wells are summarised in table 1.

priv / com	Nitrate (mg/l)	Depth (m)	Water table(m)	Water layer(m)	cement	wall	state	roof
Nitrate (mg/l)	x	+,P=0.001	+,P=0.00	+,	-, p= 0.354	P=0.956	-p= 0.433	-,P= 0.012
Depth (m)	+,p= 0.198	x	+, p=0.00	+,p=0.05	*	*	*	*
Water talbe(m)	+,p= 0.274	+,p=0.000	x	+, n.s.	*	*	*	*
Water layer (m)	+, p= 0.0973	+, n.s	+, n.s.	x	*	*	*	*
Cement	-,p=0.028	*	*	*	x	*	*	-p= 0.0029
Wall	-,p= 0.253	*	*	*	*	x	*	-,p=0.47
state	-, p= 0.031	*	*	*	*	*	x	*
cover	-. P=0.021	*	*	*	+,p=0.028	+,p=0.254	+,p=0.031	x

Table 1. Correlation's and their significance of the variables (significance is $p \leq 0{,}05$)

For the common wells, the state of the cement and the presence of a roof were significantly related with nitrate. The better the cement, the lower the nitrate contents. The common and private wells with a cover have a significantly lower nitrate content and significantly better cement.
The more nitrate is found in a private well, the deeper that well, the deeper the water table and the larger the water layer.
The nitrate concentration of common wells with a roof is not related to the state of cement (p= 0.82746).
The nitrate concentration of common wells without a roof is not related to the state of cement (p= 0.143263).
The nitrate concentration of common wells with a good state of cement (2,3) is not related to the presence of a roof. (p= 0.471).
The nitrate concentration of common wells with a bad state of cement (0,1) is not related to the presence of a roof. (p=0.067).

The compared means of private and common wells for all measured values can be seen in table 2:

	n	Depth (m)	Water table(m)	Water layer (m)	Nitrate (mg/l)	Cement	Wall	State	Roof	Cover	guard

com	39	18.517	17.818	0.699	64.74	1.38	1.77	3.154	0.51	0.051	0.462
priv	15	18.517	16.587	1.987	44.67	1.8	2.73	4.533	0.4	0.6	0.133
mean difference		0	1.231	-1.288	20.08	-0.4	-1	-1.37	0.11	-0.549	0.328
sign mean diff		0.935	0.0616	1.12E-09	0.154	0.22	0	0.00279	0.47	9E-04	0.01

Table 2. Comparison of variables means between common and private wells.

The private wells have a higher water table and a significant larger water layer, but are not deeper than the common wells. They are in a better state and are more often covered.
The compared means of wells with nitrate contents <50 and ≥50 mg/l, can be seen in table 3:

	n	Depth (m)	Water table (m)	Water layer (m)	Nitrate (mg/l)	Ceme nt	Wall	State	Roo f	Cover	guard	#pri vat
nitrate 15-40 mg/l	27	17.95	16.75	1.203	28.7	1.78	2.19	3.96	0.56	0.296	0.296	11
nitrate 50-200 mg/l	27	19.11	18.2	0.909	89.63	1.22	1.89	3.11	0.41	0.111	0.444	4
mean difference		-1.154	-1.448	0.294	-60.93	0.56	0.3	0.852	0.15	0.185	-0.15	
sig. means diff		0.0602	0.0137	0.186	0	0.07	0.16	0.0440	0.28	0.095	0.268	

Table 3. Comparison of means between polluted and less polluted wells.

Wells with less nitrate have a significant lower water table and a better state.

The nitrate values found in room temperature in comparison to the same well outside are shown in table 4. Measured at room temperature the nitrate found is slightly higher than has been measured outside.

Outside sample nitrate (mg/l)	second sample nitrate (mg/l)
>10	<25
<25	<50
25	<50
>25	50
>25	50
>25	<50
<50	50
<50	50
50	100
50	<100
>50	50
>50	<100
<100	100
100	<250
>100	>100
<250	250

Table 4. Nitrate rates measured outside and inside compared.

One well was found with a nitrate concentration of <500 mg/ml. This was not taken into account with the statistical analysis because the depth was unknown. It had an unpleasant taste.
In at least six communal wells the water was turbid or with particles. In one a worm was found which looked like a tubifex worm.
The spreading of water table, well depth and nitrate content are shown in maps 1-3. High nitrate levels seem to be clustered to the center of the village.

5. Possible solutions

Before we move on to the discussion, the attempt of WECF to pose a solution for groundwater pollution and insufficient sanitation is described. For comparison the (different) solution of a neighbour village is described.

5.1 Project 'Safe drinking water'

On forehand the high nitrate levels and the many micro-organisms were known. It was assumed by M&S and WECF, that the pit latrines were the cause of the high nitrate and many microorganisms in the well water. To make an attempt to avoid groundwater pollution by pit latrines, 'no mix toilets', or ecosan toilets are installed in one of the schools. The faecals are caught separated from the urine. Both are stored in tanks to decompose. The faecals are coverd with earth and ashes and stored a year. After decaying it will be free from pathogen micro-organisms. The Urine is stored at least one year. Both treated urine and faecals can be used very well as fertilisers or soil improvers for agriculture and garden. Urine contains the three for plants essential elements (nitrogen, phosphor and potassium) in the right proportions. In this way the 'cycle of nutrients' can be closed. The farmers don't have to buy expensive fertilisers and latrines do not pollute the groundwater. If this organic fertiliser is used in the right proportions at the right times it will not contaminate groundwater (WECF, 2002). Villagers have the possibility to install ecosan toilets in their homes. The ecosan toilets in the school serve as a model and have an educational function. They show a way to solve the drinking water problem. Possibilities for sanitation in the village are limited. Water has to be taken out of the well and hands are washed with the help of a cup. Washing-basins were installed in the two schools and the dispensary, so the children, doctors and patients are able to wash their hands. For vulnerable groups (young babies and pregnant and breast feeding women) filters were installed at the two schools and the dispensary, so they have access to clean and safe drinking water. An information campaign was and will be held, people were informed about sanitation, drinking water, wells and hygiene. Wells with high nitrate levels have been marked by warning posters. Some teachers held (voluntary) classes in school about ecological education to promote the ecosan toilets and safe drinking water. In spring 2004 a villager will renovate some of the common wells as delayed project work.

The design of the project was made to promote democracy building, community mobilisation citizen’s participation and gender. A village committee has been installed. Its function was to supervise the project and to take part in decision making, in collaboration with the local NGO workers. All layers of society and the local authorities were encouraged to make part of the committee. For several reasons it never functioned well, and eventually it was cancelled.

Intensive farming is known to pollute the groundwater with nitrate and pesticides, so it would be appreciated if farmers change now to organic farming. Most farmers don’t use, or use very little artificial fertiliser and pesticides, mainly because of lack of money. At this stage it is easier, with some assistance of experts, to change to organic farming because in fact it is already practised. An organic farming expert from Wageningen visited the village to investigate the possibilities and discussed the situation with the people.

An excursion to an organic farm in Transylvania (a region in Romania) was organised in November 2003 for 27 farmers from Gârla Mare to get information and ideas about organic farming. Five women have visited the international exposition of organic farming in Nuremberg (19 –22 February 2004). Due to the excursions, villagers are aware that organic farming is better for the environment and the health. A lot of them are willing to practise organic agriculture and they have great expectations on exporting organic products to the EU to make more money.

5.2 Women organisation

To realise the aims of the project ‘Safe drinking water’, a lot of difficulties were met. This was, among others, due to the lack of (social) structures and the fact that the village was in economic misery. To create better circumstances for further development, a local women group was initiated by Riti Herman-Mosterd from the University of Wageningen in November 2003. The goal of this organisation in the making is to work on a better and cleaner future for Gârla Mare. Steps still have to be done to establish a democratic and on equality based group. The group discussed together with Riti the main problems in the village and gave them priority; the first concern was health, than (un)employment, social problems and environment. A lot of good ideas for possible solutions came up at a brainstorming session. Mentioned were, among others, a farmers association for organic farming, a solution to the waste problem, a tailors

atelier, a social meeting place for young people, promotion of the ecological toilets and a hairdressers shop. Decided was to concentrate on organic farming, a solution to the waste problem and a tailor's atelier.
The organic farming will help to protect the water quality.
The waste management will solve an important problem and will have an example and educational function. Waste is deposed over the edges of the village, including carcasses of dead livestock and pig manure. This poses a potential health threat and looks untidy.
The tailor's atelier reduces the very high unemployment, especially for women. People will be able to improve their economical situation and obtain a higher living standard.
Five women from the organisation visited the international exposition for organic agriculture in Nuremberg to make contacts, get ideas and get a better understanding of the branch and Western Europe.
Beside the practical advantages the women's group will help to democratise the village. It will promote citizen's participation, community mobilisation and gender aspects.

5.3 A different approach; Pristol.

In some of the neighbour villages a foreign firm constructed a central water supply, financed mainly by the SAPART program (Special Program of Pre-Accession for Agriculture and Rural Development) by the EU. One of the villages is Pristol, three kilometres from Gârla Mare. The firm made a contract with the local authorities. A private water supply in the house costs 100,- Euro. In the village every 250 meter a public water pump is installed. The vice mayor thinks there will be enough people interested in having running water at home.
The installation wasn't working at the time when visited, there was not yet electricity. A basin will be filled by 30-meter deep wells at a distance of 50 meters from each other.
Some villagers stated that they have good water in their court so they won't use central water supply. In other parts of the village the wells were dried up probably due to some extremely dry summers. Inhabitants of that part said they would use the central water supply.
This project wasn't discussed with the villagers and the villagers didn't participated. They didn't know how much they have to pay for a water supply in their homes. The firm 'just' came and built it. The construction work made progress a lot faster than in Gârla Mare.

6. Discussion and conclusions

6.1 Health

The on micro-organisms tested well's didn't even fulfil the EU guidelines for bathing water quality, because of the high counts of micro-organisms. The presence of E.Coli and faecal streptococci is evidence that the wells are contaminated with human faeces. This is a potential threat due to possible contamination by pathogenic organisms. Diseases can be spread through the drinking water. Small babies are especially at risk to get ill from pathogenic E.Coli.

The nitrate levels found in the measurements of WECF exceed the limit up to 10 times. The most severe problem with this is the threat of baby blue disease. The risk is enlarged due to the combination of bacteria and nitrate. Fortunately cases of baby blue disease didn't occurred the last years in Gârla Mare but there is a potential risk. The risk on cancer caused by nitrate is not apparent in most cases.

The effect of nitrate on the thyriod gland still has to be investigated. But it is clear that problems exist.

The maximum allowable daily intake rate (3.65 mg Nitrate/kg bodyweight) is for adults higher than the maximum rate of 50 mg/l in drinking water, which is based on vulnerable groups. Nitrogen intake by vegetables is also taken into account when setting these limits. (Samwel, 2002). Though nitrogen concentrations above 300 mg/l can not be good for anyone. Often people are aware if wells have 'good' water or not.

Atrazine levels exceed the limit 5 to 1,5 times. This poses a risk on cancer and on the general state of health among vulnerable groups. The Sipot spring is not appropriate for drinking water due to the high atrazine level. All other values there are acceptable.

Worms and turbidity should never be present in drinking water for humans.

6.2 Nitrate data

In this research, it is assumed that the main source of the nitrate in well water are latrines. The exact distance between the wells and latrines was not measured, because it was complicated (the houses were in between), due to time constraints and the distance was more than the 20 meters set in the proposal. Normally people were aware that latrines shouldn't be constructed near to wells.

The nitrate contents measured by WECF in summer are higher than the nitrate contents measured during this research in autumn. The local NGO-worker stated that nitrate was commonly higher in summer than in winter. This may be due to the different conditions in the seasons. In autumn and winter it rains a lot, so the soil will be wetter. In the summer the soil is dryer and warmer. Parkin (1990) found a positive correlation between soil water and denitrification. The pores are filled with water and create more anaerobic conditions, were denitrification in stead of nitrification is more likely to take place. The temperature will influence microbiological activity, at low temperature less nitrification will take place in the upper layers of the soil. The high quantities of rain may dilute the polluted groundwater. In this case the rainwater does not wash out noticeable nitrate into the groundwater, as is the case in nitrate pollution from agriculture. In agriculture surpluss nitrate from fertilizer is washed out into the groundwater in the winter, when it rains a lot and no vegetation is present (Sonnthemer, 1985). That this is not the case in Garla Mare is another indication that the nitrate origines from latrines.

The deeper the private well, the higher the nitrate. This is also a trend (not significant) in the common wells. The explanation can be, that the longer the urea/ammonia stays in aerobic zones, the more nitrification can take place. The deeper the well, the farther the way to the saturated zone and the longer the stay in the aerobic zone. In this case the filter function for nitrate is not apparent. If the filter function was noticable, less nitrate would have been expected in deeper wells. The deeper the well, the longer the (soil) filter (Jackson, 2001).

The wells with high nitrate concentration seem to be clustered to a certain region of the village. Also the deeper wells seem to be clustered at this region (see maps appendix 2). The correlation between depth and nitrate may thus also caused by the region. The house density there is probably higher and pollution more intensive. The center may be situated on the highest part of the village, so the wells must be deeper there. This supports the hypothesis that the latrines are the cause of the pollution, in the center the latrine density is higher.

The nitrate difference may also be due to the different soil properties between regions. That the wells at that region are deeper may be without relation. To get a better sight on the situation and test the hypothesis that nitrification and/or denitrification play a role, measurements of ammonia and urea in the groundwater are needed to see if nitrification is incomplete when arriving to the anaerobic zone. Some soil samples should be taken, by drillings as deep as the wells to investigate the type of soil and make a closer estimation of the filtering and nitrification rates of the particular soils from literature.

In Gârla Mare it is difficult to say something about the relations, because to few parameters are known. Beside that, most of the studies of latrines and groundwater pollution have been done in tropical regions were circumstances (climate, soils) are different from European areas.

Wells with a roof are mostly well sealed with cement. It is not clear weather the reduction of nitrate is caused by the roof or by good cement. Both factors will have a positive effect on water quality. The state of the wall doesn't seem to have an effect on the nitrate content.

Private wells are better maintained for social reasons. Further measurements are needed to clarify why they have a bigger water layer but are not deeper than common wells. It should not be possible that there is a difference in water table between common and private wells.

The turbidity and the worm are found in communal wells probably due to mismanagement and the lack of a cover. The turbidity consists probably of organic materials, brought by the wind and entered the well. In the presence of organic materials organisms like the worm can persist.

It is not clear why the well in which were found <500 mg/l nitrate has such an exceptional high rate and an unpleasant taste. Probably a special earth layer was underneath the well which caused the unpleasant taste. Only by a drilling and a chemical analysis this can be found out.

6.3 Technical constrains

The data on nitrate are not very accurate, because they were obtained under varying temperatures. The test strips are only accurate above 10°C. From the 16 samples tested again at room temperature it was not possible to determine an exact standard error to correct all the values. But the variation was within limits. It was possible to work with the initial dates, they indicate weather a well is more polluted than another or not. In this case the exact values do not matter so much, only the differences between the values is important when the approximate standard error is known.

The nitrate measurements were taken within a period of several weeks. The nitrate concentrations may have differed in time due to rainfall or temperature.

For the well depth and the water table the meters were measured exact, the centimetres were estimated, which is not an exact method, but sufficient for this study.

During measuring, the researchers attention was distracted by curious villagers, so occasionally measurements had to be repeated.

7. Discussion on sociology and sustainable development

It is not as simple as it seems to improve water quality. This section describes some of the social and practical problems a development worker meets when working on a water project in a Romanian village.

7.1 Social support

The common opinion is that the water is of good quality. The doctors state that they don't observe many illnesses related to water. A few cases of baby blue disease occurred in the past. I didn't had any symptoms when I drunk every day the water from the 'polluted' wells during my stay. The faecals found in the ecosan toilets mostly looked normal and diarrhoea was not observed there. These observations have been done in autumn (November-December 2003), when temperatures are moderate and bacteria don't have the same growth capacity as in summer. Though not very apparent, for small babies and pregnant women the polluted water is a realistic threat. But it is very questionable if pregnant women and young mothers will go all the way to the dispensary to get a few litres of clean water, not realising the danger of well water and having limited time. The doctors and randomly questioned villagers mentioned problems with the thyroid glands and high blood pressure most frequent health problems. They don't seem aware that the problems with the thyroid glands may be very well caused by high nitrate levels. High nitrate levels cause decrease intake of iodine.

In fact, for most villagers things didn't changed after the project. As found by discussing with the women group, questioning people at random and as observed in peoples homes, in Gârla Mare exist more urgent problems than water quality. Villagers are more worried about earning enough money and growing enough crops to feed the family, than about contaminated water. In parts of the Roma community malnutrition is a problem. (Food) hygiene in both Roma and Romanian community can be a problem in summer (own observations, 2003).

Another obstacle in Gârla Mare for the introduction of ecosan toilets in private homes was that people find it a strange idea to have sanitation inside the house. They are used to have sanitation in their backyard. But ecosan toilets outside are at risk of freezing (Jacks, 1999). This situation makes it harder for villagers to understand the sense of the project. Though people have other problems in daily life, the sanitation and water quality should be improved, at the latest when Romania enters the EU (2007). Ecosan toilets are a by experts widely accepted solution for small scale sanitation and groundwater protection and have many other advantages (Otterpohl, 2003).

But only when ecosanitation is accepted and wanted by the inhabitants of a village, it can be introduced successfully in that community. Because villagers have different problems and don't see direct problems with the usual way of sanitation or with water quality, this is difficult to reach but not impossible. As former Communist country, Romania is still in transition. 'Democratisation' and 'development' is a difficult process and takes a lot of time and energy.

7.2 Problems on the spot

Like in most villages, in Gârla Mare quarrels between neighbours and between and within families play a role in everyday life. Some people don't talk to each other for years. Gossip is very common. The two doctor's practices don't co-operate or communicate. To which doctor a villager goes for treatment is already a statement for one of the two parties.

The more serious conflict is between the Roma and Romanian community. On both sites exist too much prejudices and misunderstandings, and Roma are discriminated in public life (more details see report on Roma, Samwel 2004).

From the beginning on the mayor was involved in the project. At the end of the project he stopped collaboration with M&S and eventually also with WECF, because in his point of vieuw things didn't went correct and local rules and costumes were disrespected.

The foreign and local development workers had to supervise the remaining construction work. It often took a lot of time to buy materials in the city or in the market place of another village. Transport had to be arranged every time.

For different types of work, different constructors had to be found. This was on one hand positive, because more people could be involved and profit from the project. On the other hand it made things more complicated. There was little communication between the workers, each one did his own job and didn't think of the construction as a whole. The supervisors, being non-professionals, had to think of all the technical details. For example, the electrical cable to the pump was forgotten when laying the pipes. So the furrow had to be digged again for the cable. This caused another delay in the constructions.

Several other technical difficulties were experienced. The villagers still lack experience with technical issues, and WECF has little insight in the local situation. This caused the filter in the school to freeze and break during the winters holiday. The local NGO worker wasn't aware to let out the water from the filter, which expands when freezing and eventualy causes the filter to break, or to take the filter into a warm place, despite of warnings from WECF. The WECF people trusted the judge of the local worker about frost dammages too much. A place inside the school building would have been more suitable for washing basins with filter.
This entourage makes development work more difficult. Personal relations and preferences of the local participants have to be taken in account. Distrust and corruption is common. The contradictions between the local partners from the city, the villagers and WECF as Westerners are difficult to overcome. This makes it difficult for the development worker to choose the right partners which he can trust.

Fig. 5. These Roma have other concerns than water quality. (Samwel 2003)

8. Recommendations

8.1 Further measurements
Further research has to be done to investigate whether the state of the cement around the well or the presence of a roof is the determining factor for a reduction of nitrate in a well. It is recommended that both are constructed for a well, as well as a cover. A cover is a physical barrier for organic matter, which can fall in the well and can not be measured by nitrate test strips.
To test the hypothesis that deeper wells have higher nitrate concentrations due too more nitrification, an ammonium/urea analysis should be done. To explain fully the difference between the wells a soil analysis should be done in several parts of the village. To understand the groundwater flows, the relief should be studied in detail.
As only the Sipot spring and some wells are tested for pesticides, it is suggested to test also the springs which flow into the lake north west of the village for pesticides. This costs money and first should be investigated if this money should not be spend on more urgent issues. Unfortunately, money is limited.

8.2 Water Quality
In Gârla Mare villagers have very limited possibilities to obtain safe drinking water. Now a filter in the dispensary is installed, at least the vulnerable groups have access to safe water. But the capacity is not big enough to supply the whole village. More information about safe drinking water is needed to motivate the vulnerable groups to use the filters. The link with iodine deficienty and nitrate should get much more attention, also from the docters site. Wells with less nitrate could be recommended for drinking water.
The final solution for this village is a central water supply and appropriate sanitation. The wells are not an appropriate drinking water source for a (future) EU country. For installing central drinking water supply a clean water source has to be found. This may be found by drilling outside the village, or at deeper layers, or as mentioned above, some clean springs may exist. Nevertheless groundwater should be protected, as it is a natural resource.
More research has to be done to investigate the health impact of the polluted drinking water and the general health situation of the population. Only little information on public health is available from the authorities.

8.3 Ecosan
Ecosan toilets for all households are recommended. A central sewage is an expensive option, may pollute the environment or the Danube, costs a lot of energy, and is not necessary! Ecosan fits very well in a small, isolated community and with biological agriculture, now there is a nitrogen lack for agriculture. The system is easy and safe to maintain.
Still a lot of lobby work has to be done to obtain acceptance at policy level. The Romanian government still needs to make a law about the use of ecosanitation products. Subsidies for people who install ecosan toilets is recommended.
Unfortunately, the village people are only insufficient interested in this kind of sanitation. To create the possibility of introduction on a village scale, and eventually regional scale, a lot of energy should be spend on social acceptance of any ecosan project. This means awareness creation, education and mobilisation should be done. For this a good framework is needed.

8.2 Good framework
The goals of the pilot project 'safe drinking water' were only partly reached. Several factors, partly described in the section above, played a role. Only if people don't need to be worried about earning enough money and growing enough crops to feed the family, they will be more likely concerned by water quality.
Under good framework conditions it is easier to realise real improvements in living conditions, water supply and quality and to introduce ecosan successfully. Good communication and collaboration among the project workers, construction workers, local authorities and WECF is very important. Practical issues need improvement as well, among others infra-structure, bureaucracy and organisation of construction workers.
For practical reasons, working on regional projects will be easier when working together with local partners present at the spot, personally concerned and motivated. For the moment it is recommended to involve also a man in supervising construction work. In general they have more insight in technical issues, and in Romania things are sometimes more complicated. This doesn't mean not to focus on gender aspects. Romanian women are as good as man to work

with in most cases. Gender aspects are still under developed in rural areas and still need improvements.
It is recommended to work on a big regional integrated project. This project is still in the brainstorming phase. Water quality, economy, organic agriculture, hygiene, gender, culture, Roma, social problems, etc., should be integrated. A new project should be developed in close collaboration with all stakeholders. Only if the entourage is suitable, real improvements in water quality and living conditions can be reached.

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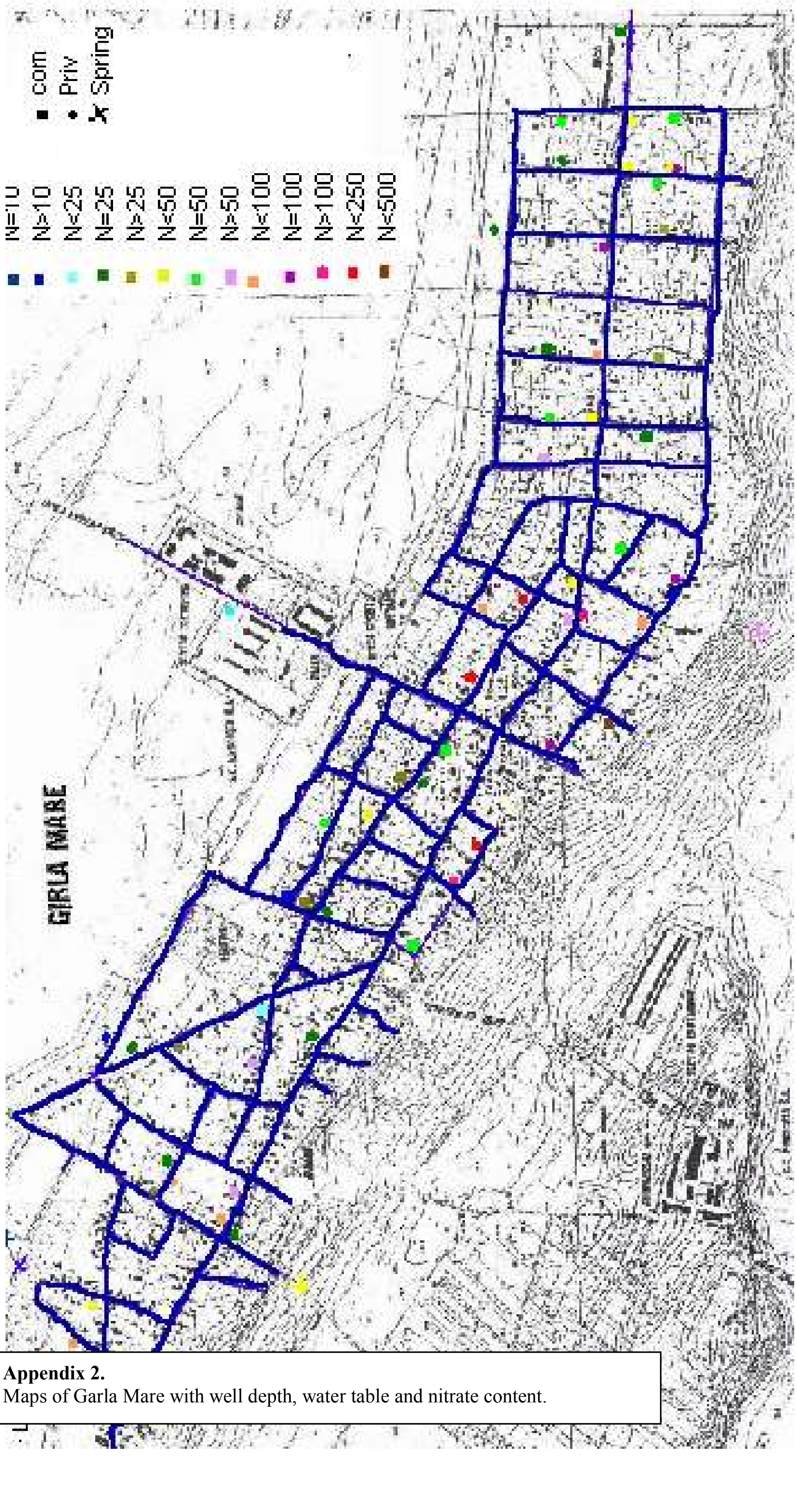
Appendix 1.

All well data.

Well nr.	Depth (m)	Water table (m)	Nitrate (mg/l)	Nitrate inside	cement	wall	coverage	guard	com/ privat e	remarks
1	19	18	<250		0	1	0	0	com	Not drunken
2	21.66	21	100	<250	1	2	0	1	com	
3	24		<500		0	3	cover	0	com	Bad taste!!
4	24.1	23.7	<100		0	3	0	0	com	turbid, worm
5	24.5	23.5	50	100	1	3	0	0	com	
6	23.6	23	100	2	2	1	0	1	com	
7										
8	21.8	21	25		2	3	0	1	com	
9	18.6	17.6	50	<100	2	2	roof	1	com	
10	18.3	17.5	>25	<50	1	1	roof	0	com	
11	18.5	17.3	<50	50	1	1	roof	1	com	
12	16.6	15.5	>25	50	0	1	0	0	com	
13	19	18.8	>25		1	1	0	1	com	
14	18.6	18	>25		3	2	Roof+cover	1	com	
15	17	16.5	50		2	3	roof	1	com	
16										
17	17.2	17	50		3	2	roof	1	com	
18			25		2	3	cover	0	priv	petrol st., narrow
19	17	16.6	25		2	2	roof	0	priv	
20	17.5	17	100		2	2	roof	0	com	
21										
22	17.5	17	<100		1	1	0	1	com	
23	17	16	25		3	3	roof	1	com	
24	18.6	18	<50		3	2	roof	0	com	
25	17	16	50		1	2	roof	1	com	
26	21.3	20.3	<50		2	2	Roof+ open cover	1	com	
27	18.2	17	<250	250	1	1	0	0	com	turbid
28	16.1	15.8	>10	<25	1	2	0	0	com	
29	17.5	16.5	<100		1	2	0	1	com	
30	18	15.5	<25		3	2	roof	0	priv	pigs
31	17	15.6	>10		1	3	0	0	priv	narrow
32			<50		3	2	0	0	com	particles in water
33	18	17.5	>50	50	1	2	roof	1	com	
34	17.3	17	<100	100	3	2	roof	0	com	
35	***		<50	50						spring
36	17.2	17	25		1	1	roof	0	com	
37	15.4	14.6	<100		0	1	0	0	com	Particles in water
38	***		>10						com	spring
39	***		10						com	spring
40	16.2	15.6	<50		2	2	roof	0	com	
41	19.5	18.5	50		0	1	0	0	com	
42	20	19	>100	>100	0	2	0	0	com	Particles in water
43	16.5	16	<25	<50	1	2	0	0	com	
44	17.7	17	>50	<100	0	1	roof	0	com	Particles in water
45	17	16.1	>25	50	3	3	roof	1	com	
46	17.5	15	25		3	3	cover	0	priv	narrow
47	16	15.6	25	<50	0	2	roof	0	com	turbid
48	19.5	16	>25		0	2	cover	0	priv	narrow
49	19	18	<100		0	3	cover	0	priv	narrow
50	17.8	16.8	<50		2	3	roof	0	priv	narrow
50	18	17	100		0	2	0	0	priv	wide

51	17.5	17	<50	2	1	roof	0	com	
52	19	17	25	3	3	Roof+cover	0	priv	narrow
53	17.3	15.8	25	2	3	cover	0	priv	narrow
54	16.5	16	50	3	2	0	1	com	
55	19	16	<50	3	3	cover	0	priv	narrow
56	19	17	25	0	3	cover	1	priv	narrow
57	17	16.3	>50	2	1	0	1	com	
58	19.2	18.5	<250	0	2	0	0	com	
59	17	15	50	3	3	Roof+cover	1	priv	narrow
60	17.5	15.5	<25	3	3	cover	0	priv	narrow
61	26	22	>100	2	3	Roof+cover	0	priv	narrow
62	22	21.2	>50	2	1	roof	0	com	
50A	17	19.2	<50	3	3	cover	0	priv	narrow
Sipot			>50						spring



Appendix 2.
Maps of Garla Mare with well depth, water table and nitrate content.