Assessment of Physicochemical Properties of Drinking Water Quality in Elbasan District

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Abstract: Natural water contains different types of impurities that are introduced into aquatic system through different ways such as weathering of rocks and leaching of soils, dissolution of aerosol particles from the atmosphere and from several human activities, including mining, processing and the use of metal-based materials. The availability of good quality water is a crucial feature for preventing diseases and improving quality of life. The present study was carried out with the aim to assess of water quality using physico-chemical parameters of wells water, in Elbasan district. In order to accomplish this aim, water samples from private wells in the villages Labinot fushë, Gjergjan, Papër, Shushicë, and Bradashesh were taken and chemically analysed. The physical and chemical parameters such as water ph, conductivity, total hardness, chlorides, ammonia, nitrate, nitrite, sulphate and heavy metal such as Fe were measured. The results were then compared with the Council Directive (98/83/EC) on the quality of water intended for human consumption. In some wells the parameters are over the standards, because they are not built under the right conditions. Also, the use of chemical fertilizers and synthetic pesticides is considered to have a major role in groundwater pollution. The quality of the water is also affected by the pipes amortization and as a result rust is formed. Private and collective wells should be regularly monitored, maintained and well disinfected.

Keyword: Water quality, Well, Physico – chemical parameters, Council Directive

1. Introduction

There are a number of sources of naturally occurring chemicals in drinking water. All-natural water contains a range of inorganic and organic chemicals. The former derives from the rocks and soil through which water percolates or over which it flows. The latter derive from the breakdown of plant material or from algae and other microorganisms that grow in the water or on sediments. Most of the naturally occurring chemicals for which guideline values have been derived or that have been considered for guideline value derivation are inorganic. According to the World Health Organization [1], nearly 1.8 billion of the world population is faced with the use of polluted potable water sources, and 663 million people are using unsafe drinking water sources.

Drinking water can expose people to a variety of harmful pollutants and pathogens. Public water systems use water treatment and monitoring to protect consumers from such contaminants. Generally, private wells do not receive the same services that wells supplying the public do. The water in private wells comes from rainfall that is absorbed into the ground, where it is trapped in pores and spaces. Also known as an aquifer, this "groundwater" is accessed by wells. If groundwater becomes polluted from contaminants during runoff or through seepage, it can result in illness if consumed. Potential sources of contamination include naturally occurring conditions and/or human activities. These range from minerals and metals that leach from the soil (e.g., arsenic, iron, manganese) to leakage from landfills, leaking septic tanks and pesticides [2]. Well owners are responsible for protecting their drinking water. To do so, a well owner must be aware of their well's potential for contamination and the possible health effects those potential contaminants can have.

Groundwater resources are the main source of drinking water in Albania. About 70% of the main cities are supplied by groundwater wells and 50% of the rural population had access to piped water. In order to cope with the lack of piped water supply, rural households dig their own wells without any monitoring of the water quality. In some cases, wells are dug on the banks of heavily polluted rivers, whose waters are unsuitable for human consumption. Lack of sanitary protection zones is causing contamination of groundwater sources. Investigation has reported that 73% of drinking wells were bacteriologically contaminated [3, 4, 5, 6, 7].

Water quality of different sources can be evaluated using physicochemical and biological parameters. This study assesses the quality of wells water in Elbasan district, using physicochemical parameters (pH, conductivity, total hardness, chlorides, Ammonia, nitrate, nitrite, sulphate and Fe). The samples are taken from villages Labinot fushë, Gjergjan, Papër, Shushicë, and Bradashesh. The analytical results of parameters were evaluated based on the Council Directive (98/83/EC) [8], the quality of water intended for human consumption.

2. Materials and Method

- **Study area**

This study has been conducted in several villages of the city of Elbasan; Labinot Fushë, Gjergjan, Papër, Shushicë and Bradashesh. These villages are over populated the recent years and are known for the development of agriculture, farming, industry and their beautiful nature.

Table 1. Geographical coordinates of study Villages

Nr	Villages	Location
1	Labinot fushë	41°14'36.5"N 20°14'66.8"E
2	Gjergjan	41°93'75.1"N 20°00'83.7"E
3	Papër	41°05'52.2"N 19°95'40.7"E
4	Shushicë	41°09'26.3"N 20°15'65.9"E
5	Bradashesh	41°06'09.3"N 20°01'29.4"E

In this village, people used two types of drinking water wells:

1. Dug wells are holes in the ground dug by shovel or backhoe. They are lined (cased) with stones, brick, tile, or other material to prevent collapse. Dug wells have a large diameter, are shallow (approximately 10 to 30 feet deep) and are not cased continuously.
2. Drilled wells are constructed by percussion or rotary-drilling machines. Drilled wells can be thousands of feet deep and require the installation of casing. Drilled wells have a lower risk of contamination due to their depth and use of continuous casing.

These wells are also used for irrigation and agriculture.

- **Water sampling and analyses**

In every village, eight water samples are taken in different wells. Water samples for study were taken according to APAT [9], 1030 method using 500 ml sterile bottles, where the date and place of sampling was noted.

Physical chemistry testing is done according to APAT [9], guidelines.

- pH method 2060
- Electrical conductivity (EC) at 20°C method 2030
- Hardness method 2040
- Chloride (Cl^-) method 4090

- Ammonium (NH_3) method 4030
- Nitrate (NO_3^-) method 4040
- Nitrite (NO_2^-) method 4050
- Sulfate (SO_4^{2-}) method 4140
- Iron (Fe) method 3160

3. Result and Discussion

- pH

pH is an important parameter in evaluating the acid–base balance of water. It is also the indicator of acidic or alkaline condition of water status. Council Directive (98/83/EC) [8] has recommended maximum permissible limit of pH from 6.5 to 9.5. The current investigation ranges were 7.1-8.0 in Gjergjan, 7.3-8.3 in Shushicë, 7.4-7.8 in Labinot fushë, 7.2-7.6 in Papër and 7.3-7.8 in Bradashesh, which are in the range of standards.

- Electrical conductivity (EC)

Electrical conductivity is an indicator of the water's ability to continue electricity, which is influenced by the number of salts and mineral content dissolved in the water. As this property is related to the ionic content of the sample, which is in turn a function of the dissolved (ionisable) solids concentration, the relevance of easily performed conductivity measurements are apparent [10]. In the study the conductivity at 20°C ranges 477-1390 µS/cm in Gjergjan, 272-489 µS/cm in Shushicë, 297-666 µS/cm in Labinot fushë, 620-1040 µS/cm in Papër and 403-820 µS/cm in Bradashesh, which are within the water limit for consumption based on Council Directive (98/83/EC) [8] standards, 2500 µS/cm (20°C).

Table 2. Drinking water quality in Gjergjan

Sample no.	pH	EC µS/cm (20°C)	Hardness °F	Cl^-	NH_3	NO_2^-	NO_3^-	SO_4^{2-}	Fe µg l^-
				mg l^-					
1	7.5	598	36	24.82	< 0.02	< 0.02	23	< 25	<10
2	8.0	477	25	28.36	< 0.02	< 0.02	4	< 25	<10
3	7.5	631	37	14.18	< 0.02	< 0.02	1	< 25	<10
4	7.4	982	53	46.09	0.56	< 0.02	95	77	<10
5	7.4	690	44	17.73	< 0.02	< 0.02	3	28	<10
6	7.4	632	39	21.27	< 0.02	< 0.02	6	< 25	<10
7	7.4	1390	80	85.08	1.17	< 0.02	99	100	<10
8	7.4	960	57	46.09	< 0.02	< 0.02	70	65	<10
Council Directive (98/83/EC)	6.5 – 9.5	2500	15-50	250	0.5	0.5	50	250	200

- Hardness

Hardness is a natural characteristic of water, which can enhance its palatability and consumer acceptability for drinking purposes. Health studies in several countries in recent years indicate that mortality rates from heart diseases are lower in areas with hard water [10]. Hardness in water is caused by a variety of dissolved polyvalent metallic ions, predominantly calcium and magnesium cations. It is usually expressed as milligrams of calcium carbonate per litre. Hardness is the traditional measure of the capacity of water to react with soap, hard water requiring considerably more soap to produce a lather. Natural and treated waters have a wide range of mineral content, from very low levels in rainwater and naturally soft and softened water to higher levels in naturally hard waters [11].

The current investigation ranges were 25-80 °F in Gjergjan {three samples (52 °F, 53°F and

80°F) are over the limit of Council Directive (98/83/EC) [8]15-50 °F}, 15-31°F in Shushicë, 15-33 °F in Labinot fushë, 33-62 °F in Papër {two samples (56 °F and 60°F) are over the limit of Council Directive (98/83/EC) [8]} and 24-68 °F in Bradashesh [two samples (62 °F and 68°F) are over the limit of Council Directive (98/83/EC) [8].

- Chloride (Cl^-)

Chloride exists in all natural waters, the concentrations varying very widely and reaching a maximum in sea water (up to 35000 mg l^- Cl). In fresh waters, the sources include soil and rock formations, sea spray and waste discharges. Sewage contains large amounts of chloride, as do some industrial effluents. At levels above 250 mg l^- Cl water will begin to taste salty and will become increasingly objectionable as the concentration rises further. However, external circumstances govern acceptability and in some arid area's waters containing up to 2,000 mg l^- Cl are consumed, though not by people unfamiliar with such concentrations. High chloride levels may similarly render freshwater unsuitable for agricultural irrigation [10]. Council Directive (98/83/EC) [8] has recommended maximum permissible limit of chloride 250 mg l^-. The current investigation ranges were 14.18-85.08 mg l^- in Gjergjan, 8.9-12.4 mg l^- in Shushicë, 16-34 mg l^- in Labinot fushë, 19-58 mg l^- in Papër and 16-34 mg l^- in Bradashesh, which are in the range of standards.

Table 3. Drinking water quality in Shushicë

Sample no.	pH	EC µS/cm (20°C)	Hardness °F	Cl^-	NH_3	NO_2^-	NO_3^-	SO_4^{2-}	Fe µg l^-
				mg l^-					
1	8.2	398	25	8.9	< 0.02	< 0.02	2	< 25	<10
2	8.3	401	25	10.6	< 0.02	< 0.02	5	< 25	<10
3	8.3	482	31	12.4	< 0.02	< 0.02	2	< 25	<10
4	8.2	392	24	10.6	< 0.02	< 0.02	2	< 25	<10
5	7.9	272	15	8.9	< 0.02	< 0.02	4	< 25	<10
6	7.3	471	23	12.4	< 0.02	< 0.02	7	< 25	<10
7	7.4	426	22	10.6	< 0.02	< 0.02	3	< 25	<10
8	7.3	489	27	12.4	< 0.02	< 0.02	0	< 25	<10
Council Directive (98/83/EC)	6.5 – 9.5	2500	15-50	250	0.5	0.5	50	250	200

- Ammonia (NH_3) mg l^-

Ammonia is generally present in natural waters, though in very small amounts, because of microbiological activity, which causes the reduction of nitrogen-containing compounds. When present in levels above 0.1 mg l^- N, sewage or industrial contamination may be indicated [10]. Council Directive (98/83/EC) [8] has recommended maximum permissible limit of ammonia 0.5 mg l^-. In the study, ammonia is in the limit (< 0.02) in all the villages.

Table 4. Drinking water quality in Labinot fushë

Sample no.	pH	EC µS/cm (20°C)	Hardness °F	Cl^-	NH_3	NO_2^-	NO_3^-	SO_4^{2-}	Fe µg l^-
				mg l^-					
2	7.7	333	15	16	< 0.02	< 0.02	2	< 25	<10
3	7.4	440	22	16	< 0.02	< 0.02	8	< 25	<10
4	7.8	423	22	18	< 0.02	< 0.02	10	< 25	<10
5	7.8	297	16	16	< 0.02	< 0.02	2	< 25	<10
6	7.7	560	29	23	< 0.02	< 0.02	25	< 25	<10
7	7.6	666	33	34	< 0.02	< 0.02	64	< 25	<10
8	7.8	460	24	23	0.60	< 0.02	15	< 25	<10
Council Directive (98/83/EC)	6.5 – 9.5	2500	15-50	250	0.5	0.5	50	250	200

- Nitrite (NO_2^-)

Nitrite exists normally in very low concentrations and even in waste treatment plant effluents levels are relatively low, principally because the nitrogen will tend to exist in the more reduced (ammonia; NH_3) or more oxidised (nitrate; NO_3^-) forms. Because nitrite is an intermediate in the oxidisation of ammonia to nitrate, because such oxidation can proceed in soil, and because sewage is a rich source of ammonia nitrogen, waters, which show any appreciable amounts of nitrite, are regarded as being of highly questionable quality. Levels in unpolluted waters are normally low, below 0.03 mg l^- NC). Values greater than this may indicate sewage pollution [10]. Council Directive (98/83/EC) [8] has recommended maximum permissible limit of nitrite 0.5 mg l^-. In the study, nitrite is in the limit (< 0.02) in all the villages.

- Nitrate (NO_3^-)

Relatively little of the nitrate found in natural waters is of mineral origin, most coming from organic and inorganic sources, the former including waste discharges and the latter comprising chiefly artificial fertilisers. However, bacterial oxidation and fixing of nitrogen by plants can both produce nitrate. Interest is centred on nitrate concentrations for various reasons. Most importantly, high nitrate levels in waters to be used for drinking will render them hazardous to infants as they induce the "blue baby" syndrome (methemoglobinemia). The nitrate itself is not a direct toxicant but is a health hazard because of its conversion to nitrite, which reacts with blood haemoglobin to cause methemoglobinemia. Of increasing importance is the degree to which fertiliser run-off can contribute to eutrophication problems in lakes. Sewage is rich in nitrogenous matter, which through bacterial action may ultimately appear in the aquatic environment as nitrate. Hence, the presence of nitrate in ground waters, for example, is cause for suspicion of past sewage pollution or of excess levels of fertilisers or manure slurries spread on land. (High nitrite levels would indicate more recent pollution as nitrite is an intermediate stage in the ammonia-to-nitrate oxidation) [10]. In the study, nitrate ranges 1-99 mg l^- in Gjergjan [three samples (70 mg l^-, 95 mg l^- and 99 mg l^-) are over the limit of Council Directive (98/83/EC) [8] 50 mg l^-], 0-7 mg l^- in Shushicë, 2-64 mg l^- in Labinot fushë Gjergjan [one samples 64 mg l^- is over the limit of Council Directive (98/83/EC) 50 mg l^-], 2-88 mg l^- in Papër [two samples 64 mg l^- and 88 mg l^- are over the limit of Council Directive (98/83/EC) [8] 50 mg l^-] and 2-32 mg l^- in Bradashesh. All the samples in Shushicë and Bradashesh are within the water limit for consumption based on Council Directive (98/83/EC) [8] standards, 50 mg l^-.

Nitrate (NO_3^-) is found naturally in the environment and is an important plant nutrient. It is present at varying concentrations in all plants and is a part of the nitrogen cycle. Nitrite (NO_2^-)

is not usually present in significant concentrations except in a reducing environment, because nitrate is the more stable oxidation state. Nitrite can also be formed chemically in distribution pipes by *Nitrosomonas* bacteria during stagnation of nitrate-containing and oxygen-poor drinking water in galvanized steel pipes, or if chlorination is used to provide a residual disinfectant. An excess of free ammonia entering the distribution system can lead to nitrification and the potential increase of nitrate and nitrite in drinking water. Nitrate can reach both surface water and groundwater because of agricultural activity (including excess application of inorganic nitrogenous fertilizers and manures), from wastewater disposal and from oxidation of nitrogenous waste products in human and other animal excreta, including septic tanks. Nitrate can also occasionally reach groundwater because of natural vegetation. Surface water nitrate concentrations can change rapidly owing to surface runoff of fertilizer, uptake by phytoplankton and denitrification by bacteria, but groundwater concentrations generally show relatively slow changes. Nitrate and nitrite can also be produced because of nitrification in source water or distribution systems [11].

Table 5. Drinking water quality in Papër

Sample no.	pH	EC µS/cm (20°C)	Hardness °F	Cl^-	NH_3	NO_2^-	NO_3^-	SO_4^{2-}	Fe µg l^-
				mg l^-					
1	7.3	1040	62	58	0.02	< 0.02	88	130	<10
2	7.6	942	46	30	0.02	< 0.02	3	165	<10
3	7.5	620	33	21	< 0.02	< 0.02	2	< 25	<10
4	7.3	644	36	23	< 0.02	< 0.02	10	< 25	<10
5	7.5	780	43	32	< 0.02	< 0.02	64	30	<10
6	7.2	805	46	37	< 0.02	< 0.02	43	28	<10
7	7.6	666	40	19	< 0.02	< 0.02	2	< 25	<10
8	7.6	944	56	41	< 0.02	< 0.02	32	105	<10
Council Directive (98/83/EC)	6.5 – 9.5	2500	15-50	250	0.5	0.5	50	250	200

- Sulphate (SO_4^{2-})

Sulphates exist in nearly all natural waters, the concentrations varying according to the nature of the terrain through which they flow. They are often derived from the sulphides of heavy metals (iron, nickel, copper and lead). Iron sulphides are present in sedimentary rocks from which they can be oxidised to sulphate in humid climates; the latter may then leach into watercourses so that ground waters are often excessively high in sulphates. As magnesium and sodium are present in many waters, their combination with sulphate will have an enhanced laxative effect of greater or lesser magnitude depending on concentration. The utility of a water for domestic purposes will therefore be severely limited by high sulphate concentrations, hence the limit of 250 mg l^- SO_4^{2-} [10]. Council Directive (98/83/EC) [8] has recommended maximum permissible limit of sulphates 250 mg l^-. The current investigation ranges were < 25-100 mg l^- in Gjergjan, < 25 mg l^- in Shushicë, < 25 mg l^- in Labinot fushë, < 25-165 mg l^- in Papër and < 25-165 mg l^- in Bradashesh, which are in the range of standards.

Table 6. Drinking water quality in Bradashesh

Sample no.	pH	EC µS/cm (20°C)	Hardness °F	Cl^-	NH_3	NO_2^-	NO_3^-	SO_4^{2-}	Fe µg l⁻
				mg l⁻					
1	7.5	702	37	14	< 0.02	< 0.02	14	< 25	<10
2	7.8	508	28	21	< 0.02	< 0.02	20	< 25	<10
3	7.2	703	41	34	< 0.02	< 0.02	20	165	<10
4	7.8	403	24	19	< 0.02	< 0.02	6	<25	<10
5	7.6	820	68	28	< 0.02	< 0.02	4	125	<10
6	7.6	511	42	16	< 0.02	< 0.02	2	45	<10
7	7.5	630	48	19	< 0.02	< 0.02	23	36	<10
8	7.3	770	62	23	< 0.02	< 0.02	32	60	<10
Council Directive (98/83/EC)	6.5 – 9.5	2500	15-50	250	0.5	0.5	50	250	200

- Iron (Fe)

Iron is present in significant amounts in soils and rocks, principally in insoluble forms. However, many complex reactions, which occur naturally in ground formations, can give rise to more soluble forms of iron, which will therefore be present in water passing through such formations. Appreciable amounts of iron may therefore be present in ground waters. Severe problems can be caused in drinking water supplies by the presence of iron although there is normally no harmful effect on persons consuming waters with significant amounts of iron. Rather, the problems are primarily aesthetic, as the soluble (reduced) ferrous (Fe^{2+}) iron is oxidised in air to the insoluble ferric (Fe^{3+}) form, resulting in colour or turbidity (or, in severe cases, precipitate formation). Laundry becomes stained if washed in water with excessive iron, and vegetables likewise become discoloured on cooking. Taste problems may also occur. When waters rich in iron are used to make tea (in which tannins are present), there may be a reaction-giving rise to off colours, which may in severe cases resemble that of ink. Problems have been reported also with the addition of such waters to whiskey [10]. Council Directive (98/83/EC) [8] has recommended maximum permissible limit of iron 200 mg l⁻. In the study, iron is in the limit (< 10 mg l⁻) in all the villages. According to EPA [10], potential well contaminant sources are:

a. Agriculture. Fertilizer storage and use, animal feedlots, animal waste disposal systems, animal burial, manure stockpiles (e.g., pits and lagoons), manure spreading, general waste disposal wells, pesticide storage and use (e.g., spread by airplane), field irrigation.
b. Industry. Oil and gas production and storage, pipelines, petroleum refineries, chemical manufacture and storage, mining, electroplating facilities, foundries, metal fabrication facilities, machine shops, waste disposal wells, paper mills, textile mills.
c. Residential. fuel oil storage tanks, household chemical storage and use, swimming pool chemical storage, septic tanks and leach fields, sewer lines, floor drains, lawn fertilizer storage and use
d. Other. Road de-icing, landfills, sewer lines, storm water pipes and drains, abandoned production and disposal wells, nearby active disposal wells, illegal dumping.

4. Conclusion

Data obtained by analysis of drinking water samples from private wells showed that physical and chemical parameters were in satisfactory range as all analysed samples were within acceptable limits recommended by Council Directive (98/83/EC). Based on the study and findings, we recommend to test wells at least once a year for mechanical problems, cleanliness, nitrates, and any other germs or chemicals of local concern. In addition, check wells after flooding or if you suspect a problem (for example, a change in taste or smell). Awareness should be raised about low or no-cost safety measures, such as boiling and chlorination of the water before intake and containing the sources of contamination through better waste and wastewater management practices, particularly due to septic tanks close to water sources.

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