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DRINKING WATER INDICATOR EVALUATION IN SELECTED DAIRY COW FARMS WITH DIFFERENT MANAGEMENT SYSTEM IN THE CZECH REPUBLIC

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Abstract

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The paper evaluates drinking water quality on selected dairy farms on the territory of the Czech Republic. The drinking water samples were collected in the farm milk storage rooms of 30 farms with subsequently made analyses. The pre – selected chemical and microbiological indicators were stated according to the regulation No. 252/2004 Coll. (pH, conductivity, chemical oxygen demand, colour, turbidity, Fe, ammonia ions, nitrites, nitrates, colony count growing at 36 °C, colony count growing at 22 °C, coliform bacteria, *Escherichia coli*, Ca, Mg, Na, K, Zn, Cu, Mn, Pb, Cr and Ni). The statistical evaluation was performed in the obtained data file and these data were compared with the limit values given by the regulation. The nitrate content ranged between 1 and 40.7 mg L^{-1} with an average of 15.6 mg L^{-1}. The pH values varied from 5.71 to 8. The chloride concentration geometrical means was 7.57 mg L^{-1} 1. The Ca average concentration 58.5 mg L^{-1} was in the middle of the recommended interval 40–80 mg L^{-1}. The geometric means in Mg content was 7.9 mg L^{-1} being under the recommended value 20–30 mg L^{-1}. The Cu, Pb, Cr and Ni limit values were not exceeded. The limit values in microbiological analyses were exceeded 18x in coliform bacteria, 10x in enterococci, 5x in *Escherichia coli*. The microbiological colonies growing at 36 °C exceeded limit 9x, those growing at 22 °C 5x.
Further, differences are compared between the organic and conventional farms, and between farms producing milk in different type of LFAs (less favourable areas) and farms not included in these areas. The difference found out between the chloride concentrations in organic (6.56 mg L^{-1}) and conventional farms (18.2 mg L^{-1}; $p < 0.05$) was statistically significant. Locality or altitude, where a given far is situated, were another classifying criterion. A significant dependence was only found out in nitrate content, which decreased ($p < 0.05$) with increasing altitude (the correlation coefficient value –0.39). It can correspond with the soil use decrease – a lesser fertilization intensity. Statistically significant differences were found out in hardness value as well as in Ca, Mg contents connected with that in all reference criterions. The hardness was clearly lower (1.13 mmol L^{-1}) in organic farms as compared with concentration 2.27 mmol L^{-1} in conventional ones. It is, however, only a supplementary indicator according to the respective regulation. No statistical significance was found among microbiological finding values in any case.

drinking water, cow, farm, microbiological quality, chemical composition, weel, desinfection, LFA, conventional farming, organic farming

Water possesses a privileged position being indispensable for life. Men and animals need abundance of water for metabolism, good nutrient absorption, for food motion in digestion tract, and tissue demand as published Adams, Sharp (1995). Drinking water quality is influenced by the source it is obtained from. Industry and agriculture as its main consumers are retrospectively also its main polluters at the same time. In order to preserve its best possible quality, it is necessary to prevent deforestation, organic waste deposition, grazing period extension in the vicinity of springs, wells and drill holes. Generally, animal grazing should be well-organized on pastures, which often predominate in small river/brook basins and whose importance increases along with agriculture out-of-production function. Dufka (2004) found that in animal concentration places such as feeding or watering places various degree of turf growth and fecal pollution occurs, thus increasing nitrogen and potassium concentrations, which can get not only into surface water but they can soak into and pollute underground water as well. The waste deposition near drinking water sources can cause both organic and chemical pollution.

Elimination of negative factors influencing primarily water quality of small sources consists in a simple protection of wells, improved sanitation, general awareness, knowledge and public education improvement. The origin of possible problems can be discovered in small and medium sources fed mostly from an identifiable catchment area. Usually they can be contaminated by rain falls, chemical pollutions, seepage from waste water trap, cesspool, septic tank, animals around the source, chemical waste deposition, incorrect drainage or a bad sewage system enabling waste water penetration, and washing and bathing in the vicinity. Organic material accumulation causes pollution growth of sources by nitrates in small village sources. Nitrates are little harmful for a man, however, they convert through bacteria reduction in mans stomach into nitirites, which can subsequently cause methemoglobinaemia. Methemoglobin is a form of hemoglobin that does not bind oxygen (Karlson et al., 1987). Ferrous ion (Fe2+) of the heme group of the hemoglobin molecule is oxidized to the ferric state (Fe3+). Nitrates can also create N-nitrosamines in the digestion tract, which are considered as potential carcinogens. Waste penetration from cesspool into drinking water source results in intermediate fecal contamination and a bad taste, stink and colour influence.

Large surface sources – rivers, lakes, dams and abundant underground water sources used for drinking water supply can be affected by a very extensive catchment area, and sometimes it is very difficult to determinate a possible source of problems. They are affected namely by pesticide and herbicide use, and sewage. The solution of specific problems cause by chemical contamination is very demanding. There are marked waterworks zones and areas with various sensitivity degree for drinking water source protection (according to the Law No. 254/2001, Czech Water Law). The degree I. areas provide water source protection in the close surroundings of caption and intake equipment, the degree II. areas serve as a source protection in the area so that quality, yield and health harmlessness could not be endangered. The care for and information about water sources rank among the most important in the present concept of organic agriculture as an effort for cleanness and suitable natural resource preservation. Therefore a surveying of used water was carried out on conventional as well as organic dairy farms. Rozsypal et al. (2007) introduced 58 organically managing farms in survey. Hajšlová et al. (2007) found lower content of nitrates at potatoes from organic farming.

In the Czech Republic, hygienic demands for drinking water, extent and control frequency are determined by the Regulation No. 252/2004. This regulation defines the limits for chemical, physical, biological and microbiological drinking water quality indicators determined for people use. This regulation is binding for dairy farms because water is used for animal watering and for cleansing purposes in obtaining and storing raw milk. The necessary supplementary water quality with fodder feeding containing about 85 % of water is smaller than with hay or concentrate feeding containing 10–15 % of water.

MATERIALS AND METHODS

Water Sampling

The drinking water samples were collected during 2 years on dairy cattle farms all over the territory of the Czech Republic. This water was collected in the farm milk storage rooms after the tap had been sterilized and after a thorough water flowing for about 5 minutes. Glass bottles for chemical analysis, sterilized vials for microbiological analysis, vials decontaminated and leached in nitric acid for macro- and microelement analysis were used. The samples were kept in cooling-boxes during transport. Most analyses were carried out within 24 hours, element determination after conservation by nitric acid within 10 days. The individual farms are situated at an altitude from 195 m to 681 m, and both the farms producing milk in LFAs (less favourable areas) and those in the areas not included (n) in this category are represented among them. The LFAs can be further divided into groups with a term(s)-specific (only 2 farms), (m)-mountain, and (o)-the others. Some of the selected dairy cattle farms are those meeting the criteria for being included in the organic farming. Altogether 30 dairy cattle farms were evaluated, most of them also furnished replenishing data about water source, its disinfection, water piping quality, and water quality monitoring frequencies.

Analytical Procedures

The samples were analysed in an accredited testing laboratory, and a drinking water analysis was carried out according to the regulation including chemical and physical analysis – pH, conductivity (Cond.), chemical demand of oxygen (COD), sulphates (SO_4^{2-}), chlorides (Cl^-), colour, turbidity, total Fe, ammonia ions (NH_4^+), nitrites (NO_2^-), nitrates (NO_3^-), and microbiological analysis – colony count at 36 °C (MO 36 °) and at 22 °C (MO 22 °), coliform bacteria (Coli) and *Escherichia coli* (E.coli). The mineral substances (Ca, Mg, Na, K), hardness determination as well as some toxic or heavy metals (Zn, Cu, Fe, Mn, Pb, Cr, Ni) determination were added to this basic profile.

The analyses were carried out in accordance with standard operation procedures and valid regulations. Determination of ammonia ions (NH_4^+) – manual spectrometric method (CSN ISO 77150-1, Spekol 11, Carl Zeiss Jena, Germany); determination of nitrates (NO_3^-) – spectrometric method with sulphosalicylic acid (CSN ISO 7890-3, Spekol 11, Carl Zeiss Jena, Germany); determination of Ca and Mg – atomic absorption spectrometry method; determination of Zn, Ni, Cu, Pb – flame atomic absorption spectrometry and atomic absorption spectrometry with a graphite cuvette (CSN ISO 8288, 7980, Spectrometer SOLAAR S4 and GF S97 Thermo Elemental, England); chlorides (Cl^-) – argentometric determination with chromate indicator (CSN ISO 9297); nitrites (NO_2^-) – molecular absorption spectrophotometry method (CSN EN 26777, Spekol 11, Carl Zeiss Jena, Germany); Na and K – emission spectrometry method (CSN ISO 9964-3; pH – potentiometrically (CSN ISO 10523, pH-meter OP 211/1, Radelkis, Hungary); sulphates (SO_4^{2-}) – capillary eletrophoresis method (EA 102, Villa-Labeco, Slovac Republic) with conductivity detection; COD_{Mn} – determination with manganese (CSN EN ISO 8467), the electrical conductivity (CSN EN 27888, OK 102/1, Radelkis, Hungary), determination of colour and turbidity – spectrophotometry method (CSN EN ISO 7887, CSN EN ISO 7027, Spekol 11, Carl Zeiss Jena, Germany). From among microbiological indicators the bacteria count growing at 22 °C (psychrotrophic bacteria, CSN EN ISO 6222) and at 36 °C (mezophilic bacteria) were determined. Agar with yeast extract was used for cultivation, the membrane filtration method with subsequent cultivation on lactose-TTC agar with Tergitol 7 was used for determination of coliform bacteria (CSN EN ISO 9308-1). Lactose-positive colonies with positive test on indol were specified as *Escherichia coli*. The membrane filtration method and selective soil according to Slanetz-Bartley were used for determination of enterococci count (CSN EN ISO 7899-2).

The analysis results are given in mg L^{-1}, determination of pH non-dimensional, conductivity in mS m^{-1}, Ca and Mg hardness in mmol L^{-1}. Certificated reference materials were used as control in all analyses. The result in coliform bacteria, enterococci and *Escherichia coli* determination is given in CFU 100mL^{-1} and bacteria count growing at 22 °C and 36 °C in CFU 1mL^{-1}.

Statistical Evaluation

Basic file parameters were determined: arithmetic mean, geometric mean (in the case of non-standard file and logarithm values distribution), median, standard deviation, variation coefficients, minimum-maximum, acuteness and obliqueness coefficients, and file normality on the basis of obliqueness coefficients. The tables show the averages used for further calculation of difference signification highlighted in bold. The *t*-test of mean value equality was used in file testing according to the selected criteria. The Wilcoxon's non-parametric test was used in microbiological indicators. A hypothesis test of two alternative distributions parameters was used in comparing some of the microelements. When evaluating the results for nitrites and ammonia ions a detection limit of quantification 0.04 and 0.05 resp. was given as minimum. The limit of detection was also given in Fe, Mn and Zn with values 0.1, 0.001 and 0.1 mg L^{-1}, resp. As most of the measured data were under the limit in these parameters, they could not be statistically evaluated and so further statistical parameters are not introduced.

RESULTS AND DISCUSSION

Water sample basic results

The drinking water samples were collected directly in the milk storage rooms. Water quality found out straight in the source can differ considerably in comparison with water quality used in stable Socha et al. (2003). When drinking water analysis is made physical, chemical properties and microbiological indicators are identified here. The basic file profiles are summarized in Table I. The examples of frequency distribution are showed at Figure 1 and 2. Nitrate concentration varied in range from 1 to 40.7 mg L^{-1}, arithmetical mean was 15.6 mg L^{-1}. It means that the requirement of the regulation was fulfilled and the limit 50 mg L^{-1} was not exceeded. A higher concentration can indicate previous pollution of organic origin because nitrates are the final oxidation stage of organically bonded nitrogen. Nitrites can be found in waters as an intermediate stage during the nitrate reduction or during the ammonia nitrogen oxidation. Their content, if there are any at all, is very small because they are very unstable. If they are found out during the analyses, it can indicate a fecal pollution. The nitrite content was under the detection limit 0.04 mg L^{-1} in most cases, the limit 0.5 mg L^{-1} was not exceeded. As for ammonia ions the measured values moved under the method detection limit, the stated limit 0,5 mg L^{-1} was exceeded in one case with the value 0.81 mg L^{-1}. Ammonia ions content in drinking water varies in tenth of mg L^{-1} at the most. The geometric mean of conductivity, which did not show any standard distribution, was 27.1 with the minimum 6.7 and maximum 95 mS m^{-1}. The geometric mean was very close to median value 27.5 mS m^{-1}. The pH value ranging between 5.71 and 8.00 showed a non-standard data distribution, however, the deviation from normality is very small and therefore the arithmetic mean 7.13 can be used for evaluation. The average value of sulphates, which together with hydrogenocarbonates and chlorides belong to the main anions of natural waters with a usual concentration of tens up to hundreds of mg L^{-1}, made 31.6 mg L^{-1}. The chloride values did not show any standard distribution, therefore transformation was used and the calculated geometry mean 7.57 mg L^{-1} got closer to median value 7.45 mg L^{-1}. Chlorides are the most current form of chlorine occurrence in water, they are considerably stable and their concentration can move in a very large range. Higher chloride concentrations of geological source naturally do not occur in our waters, however, waste waters contain them. It is, therefore, possible that the increased concentrations may have been caused by polluted waste or industry water in some cases. Hardness value 1.41 mmol L^{-1} was out of the recommended range 2.0–3.5. The Ca average concentration 58.5 mg L^{-1} was in the middle of the recommended value 40–80. The results dispersion, of course, was from 5.7 to 174 mg L^{-1}. Ca together with Mg are widespread considerably in the nature and their content depends on geological conditions. Mg as a substantial component of water hardness next to Ca, did not show any standard distribution. Geometric mean 7.9 mg L^{-1} did not reach the recommended values 20–30 mg L^{-1} and was even under the threshold value limit. Horáková (2003) showed the average concentration in the Czech Republic around 10 mg L^{-1}. Higher Mn and Fe values causing water colouring were measured in 4 cases in Fe (>0.2) and in 3 cases in Mn (>0.05). The monitored sources were mostly wells or drill holes, consequently underground water.

Where the farms miss their own sources and take water from the communal water piping, wells were the source or it was unknown. Underground water contains dissolved salts subject to soil and rock, but also to rain falls, vegetation, agriculture and industry as well. The increased heavy metal concentrations show in Tables II, III and IV did not exceed the requirements in any case. The COD determination also showed a non- standard distribution. The chemical oxygen demand is an indicator used for organic water pollution estimate. The monitored file geometrical mean was 0.48. This value, too, approaches median 0.49. Pitter (1999) presented the mean value 1.4 mg L^{-1} in underground waters. The standardized values for colour and turbidity were exceeded only in one of the monitored farm. The microbiological evaluation includes the counts of positive cases where the found values were higher than those laid down by the regulation. There were 18 (60 %) cases in coliform bacteria, 5 cases in *Escherichia coli* (17.2 %), requirement = zero value. A positive finding was above the zero value in ten cases (34.5 %) in enterococci, the colonies count growing at 36 °C exceeded the standard 20 CFU mL^{-1} in 9 cases (31 %), and the colonies count growing at 22 °C exceeded the demand 200 CFU mL^{-1} on five monitored farms (17.2 %). The microbiological contamination of drinking water used during animal watering can be a problem (diarrhea) in young animals with lowly rumens (Johnson, 2005), the influence in older animals is not evident.

Differentiation of drinking water sources

Table II shows the farm distribution according to producing areas (Decision No. 1257/1999/EC). As the first the farms classified according to the criteria as mountain LFAs are introduced. Eleven farms met this condition (higher altitude than 600 m and/or 500 m and lower than 600 m, and with a gradient above 7° on a larger surface than 50 % of agricultural land area in the community or land register). The basis chemical and physical indicators kept the standard conditions, positive findings were established in microbiological indicators. The limit in coliform bacteria parameter was exceeded 8× (72.7 %). It is evident from the table that the other microbiological parameters were exceeded, too. Two findings of positive cases were identified in Fe content. The analysed heavy metals showed a standard distribution and the concentration were under the limit values. The LFAs marked as s (defined according Decision No. 1257/1999/EC) included 2 farms only, the Fe content 0.49 mg L^{-1} was exceeded once from among all monitored indicators.

The LFA o-category (determinate according Decision No. 1257/1999/EC) contained 6 farms. The Fe and Mn contents were exceeded in one farm only. A sample with the worst microbiological indicators was analysed in this file. At the same time an increased ammonia ion and Fe concentration were measured. This water seems to come from an old non-disinfect well with an original water piping. Eleven farms marked as n do not belong to the LFAs and only microbiological criteria were exceeded from among all indicators. Five cases in coliform bacteria make 45.5 %, four in enterococci 36.4 %. A zero occurrence of *Escherichia coli* in this area is also worthy of mention.

Difference importances of indicator file averages within the framework of LFAs were stated by a single-factor analysis of variance. Significant differences in hardness, conductivity, Ca and Mg concentration values were found between the areas. These indicators were significantly lower in the m-area (0.87 mmol L^{-1}, 24.48 m Sm^{-1}, 23.28 mg L^{-1}, 4.76 mg L^{-1}) compared with the n-area (2.68 mmol L^{-1}, 50.90 mS m^{-1}, 81.8 mg L^{-1}, 14.67 mg L^{-1}, $p < 0.05$).

The farms were compared according to their managing system and divided into those fulfilling the criteria for being classified as organic farms, whereas the other group was conventional farms.

Table III shows the results of organic farming where 12 farms were included and 18 farms were in conventional system. The organic file showed the results already mentioned, i.e. it included the data from the farm with the worst microbiological evaluation. This farm misses its own well, it uses the communal water piping, and the source disinfection is probably carried out by the operator only 1–2x a year before an expected control sampling. The breeders should naturally avoid practices like these because the analysis result of water treated by disinfection closely before sampling may be faultless, however, they are short of water quality survey in the well, and information is distorted. Hanuš et al. (2007) mentioned that not always is located the drinking water source on a land with organic regime, even communal water piping are used for water supply, and so both the files cannot be separated strictly. In one organically managing farm the allowed limiting concentration was exceeded because of ammonia ion content. A lower pH value was found in two cases in conventional farms, probably owing to natural lower pH of water. The nitrate content as one of the very often monitored and discussed indicators did not exceed the allowed limit in any case. The highest established value 28 mg L^{-1} was in organic managing system, in the conventional one 40.7 mg L^{-1}. Hajšlová et al. (2005) described lower nitrate levels at products from organic husbandry. Higher concentrations can be found in higher manuring by nitrate fertilizers or barnyard manures or in the case of badly sealing waste pits. Acute poisoning by nitrates would cause nervousness, cyanosis leading to vomiting, attack and death in man. The ruminants having a developed rumen flora possess a higher capacity for nitrate reduction. MAV Technical Paper (2004) generally said, of course, that animals run a greater risk when consuming nitrates originating from grazing and feeding than by water drinking.

A statistical comparison of organic and conventional farms was carried out. The average medium altitude of the organic farms presented by Hanuš et al. (2007) was 571.0±69.9 m (from 460 to 650 m), which confirms rather a submountain up to mountain localization of these farms. Significant differences were found in hardness, Ca and chloride concentration values. Organic farms showed evidently a lower hardness value (1.13 mmol L^{-1}) than the conventional ones (2.27 mmol L^{-1}), ($p < 0.05$). It was logically so in the case of Ca (17.31 and 75.45 mg L^{-1}, rep.), ($p < 0.001$), too. The Ca values in organic farm samples moved markedly under the limiting value (LV). The chloride concentration values coming from the sample files of organic farms were also significantly lower (6.56 mg L^{-1}) than in conventional farms (18.19 mg L^{-1}), $p < 0.05$). As for Fe, psychrotrophic bacteria and *Escherichia coli*, a higher finding percentage was found out above LV (limiting value given by the regulation), respectively above permitted limit in the samples of organic farms than of conventional ones. This difference, however, cannot be proved reliably owing to the data nature their small count in the files. The calculations were executed by means of a double-selection *t*-test of medium value equality. In addition to that the Wilcox selection test was used in files with deviation from normality.

If altitude, in which the individual farms are localized, was a testing criterion, the file was divided into 3 parts (Table IV), the farms located under 350 m, those producing milk at 350–450 m, and the farms managing at a higher altitude than 450 m. Statistical significance between the individual localities ($p >$ 0.05) was not found out even in this distribution, either. The animals have sufficient water quantity on all farms. The cow in lactation has average demand of 80 liters and more a day in dependence an season and given fodder. Maynard (1992) presented that highly efficient dairy cows need up to 5 water units for a produced milk unit. A high water mineralization that could have a possible influence an animals in physiological stress, e.g. cows pregnant or in lactation, which would be more sensitive to mineral dysbalance (Anzecc, 2000), was not found out on any farm. No concentration of the mentioned heavy metals that would exceed the limits given by the regulation was found out. A positive finding was found out in 7 from among 10 (70 %) monitored coliform bacteria on farms located at an altitude of 350–450 m. The most bacteria were found in those growing at 36 °C, which indicate a general not fecal pollution. Positive findings of coliform bacteria made 50 % in the other file parts.

A significant difference was found in water hardness between the areas at smaller altitude than 350 m (2.38 mmol L^{-1}) and those at a higher altitude than 450 m (0.94 mmol L^{-1}), ($p < 0.05$). Greater but statistically insignificant differences were recorded in Ca and Mg concentrations. A single-factor analysis was used for calculation. The Figure 3 shows the dependence between the nitrate content and the altitude. The correlation coefficient value –0.39 has confirmed that the dependence is significant ($p < 0.05$). This nitrate content decrease with an increasing altitude can correspond with the soil use decrease – a lesser fertilization intensity.

A survey by questionnaire concerning used water source has show that 4 farms with their own wells observed the regulation accurately as for analysis number and extent. The others execute the analyses at random 1–2× a year and in a reduced extent only. Where a communal water piping is used, information about the executed analyses number is not sufficient. A source disinfection is not executed by 2 farms at all, manual disinfection 2–4× a year is carried out by 2 farms, 11 farms do not chlorinate, but as they use communal water source, such water will probably be disinfected by another subject, the others have installed an automatic dosing apparatus. No microbial contamination was found in both the wells without disinfection. They are mountain farms classified as organic ones situated in LFA. As far as the respondents knew, the mentioned age of the well ranged between 25 an 30 years. The oldest wells are situated in the mountain localities. In most places water is distributed in pipes of metal-plastic combination, original from zinc or cast-iron pipes are replaced by plastic ones when exchanged. The plastic pipe exchanges are 14 years old and younger. The wells were localized from 30 m up to 800 m away from the shed. If the farm used a communal water piping, the pipes length was 1.5–8 km away from the shed.

CONCLUSION

The survey shows that the exceeding of microbiological indicators is the most frequent problem. In 60 % of water samples were found coliform bacteria, the positive finding was at the colonies count growing at 36 °C (exceeded the standard 20 CFU mL^{-1}) in 31 % cases and the colonies count growing at 22 °C exceeded the demand 200 CFU mL^{-1} in 17.2 %. The positive finding was in 34.5 % samples in enterococci (above the zero value). Chemical properties and heavy metal occurrence have not proved to be a risk factor of used drinking water in dairy farming.

I: *General evaluation of selected drinking water indicators*

	pH	NO_3^- mg L^{-1}	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Cond. mS m^{-1}	COD mg L^{-1}	Cl^- mg L^{-1}	SO_4^{2-} mg L^{-1}	Hardness mmol L^{-1}	Fe mg L^{-1}	Ca mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	Colour mg L^{-1}Pt	Turbidity ZF
n	30	30	30	30	30	30	30	22	30		24	24	27	24	30	30
x	7.13	15.6			34.8	0.57	13.5	31.6	1.82		58.5	1.62	8.04	11.4	8	2
m	7.27	12.7			27.5	0.49	7.45	30.1	1.52		40.9	1.60	6.90	6.66	6	1
sx	0.48	11.9			24.2	0.40	16.3	20.9	1.29		43.7	0.64	5.66	13.5	7.89	2.38
vx	6.72	76.3			69.7	70.6	120	66.2	71.3		74.7	39.5	70.5	119	100	130
min	5.71	1.00	<0.04	<0.05	6.70	0.16	0.71	0.63	0.40	<0.1	5.70	0.50	2.20	1.70	1	0
max	8.00	40.7	0.31	0.81	95.0	2.24	56.9	77.5	5.90	1.75	174	3.20	22.4	58.5	48	14
R	2.29	39.7			88.3	2.08	56.2	76.9	5.50		168	2.70	20.2	56.8	47	14
a_3	-0.97	0.50			0.96	2.30	1.65	0.53	1.12		0.64	0.35	1.09	2.16	4.35	4.42
a_4	3.86	1.89			3.02	9.92	4.51	2.28	4.10		2.69	3.24	3.71	6.90	22.34	22.81
normality	no	yes			no	no	no	yes	no		yes	yes	no	no	no	no
xg	7.11				27.1	0.48	7.57		1.41				6.14	7.90	6.48	1.36
standard-LV	6.5-9.5	50	0.5	0.5	125	3	100	250		0.2	30	–	200	10	20	5
									2-3.5RV		40-80RV			20-30RV		

	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}
n	30	30	30	30	30
n positive	18	10	9	5	5
% positive	60.0	34.5	31.0	17.2	17.2
min positive	1	2	25	220	6
max positive	46	120	304	500	46
R	45	118	279	280	40
a_3	1.91	3.34	3.22	1.81	3.11
a_4	5.27	13.9	14.5	4.9	12.1
normality	no	no	no	no	no
xg	5	14	69	355	15
standard-LV	0	0	20	200	0

LV: limiting value, RV: recommended value, n: farm number, x: arithmetic mean, m: median, xg: geometric mean, sx: standard deviation, vx: variation coefficient, minimum, maximum, R: range, a3: acuteness coefficient, a4: obliqueness coefficients

II: *Distribution according type of farming*

	LFA: m												
	NO_3^- mg L^{-1}	Cond. mS m^{-1}	COD mg L^{-1}	Cl^- mg L^{-1}	SO_4^{2-} mg L^{-1}	Hardness mmol L^{-1}	Ca mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	pH	Colour mg L^{-1}Pt	Turbidity ZF
n	11	11	11	11	10	11	8	11	11	8	11	11	11
x	9.72	24.48	0.50	8.72	20.7	0.87	23.3	1.61	7.23	4.76	7.13	10	2
m	6.02	22.00	0.49	2.13	20.5	0.80	16.3	1.45	4.30	5.17	7.39	6	1
sx	8.02	19.02	0.24	14.9	10.7	0.52	23.0	0.66	6.24	1.76	0.63	12.6	3.88
vx	82.6	77.71	48.0	170	51.6	60.0	99.0	41.1	86.3	36.9	8.89	121	164
min	1.63	7.20	0.32	0.71	7.20	0.40	5.70	0.50	2.20	1.70	5.71	5	1
max	25.0	70.8	1.07	51.9	37.6	2.15	76.2	2.50	21.7	6.63	8.00	48	14
R	23.4	63.6	0.75	51.2	30.4	1.75	70.5	2.00	19.5	4.93	2.29	43	13
xg	–	–	–	4.02	–	–	–	–	–	–	–	8	–

	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}
n	11	11	11	11	11
x					
m					
sx					
vx					
min	0	0	0	0	0
max	46	120	304	500	46
R	46	120	304	500	46
xg	8	28	17	39	37
positive	8	3	4	2	2
% positive	72.7	27.3	36.4	18.2	18.2

	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
n	11	11	11	11	11	11	11	9	7
x				0.008	0.043		0.003	0.002	

	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
m				0.010	0.010		0.003	0.001	
sx				0.006	0.102		0.002	0.003	
vx				75.3	235		72.2	202	
min	<0.04	<0.05	<0.1	0.001	0.001	<0.1	0.001	0.001	<0.001
max	0.31	0.81	1.75	0.012	0.35	0.56	0.007	0.011	0.006
R				0.011	0.34		0.006	0.01	
xg									
positive	0	1	2	0	1	–	0	0	0
% positive	0	9.1	18.2	0	9.1	–	0	0	0

The areas not included in LFA:n													
	NO_3^- mg L^{-1}	Cond. mS m^{-1}	COD mg L^{-1}	Cl^- mg L^{-1}	SO_4^{2-} mg L^{-1}	Hardness mmol L^{-1}	Ca mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	pH	Colour mg L^{-1}Pt	Turbidity ZF
n	11	11	11	11	7	11	11	8	9	11	11	11	11
x	20.1	50.9	0.66	20.2	43.6	2.68	81.8	1.84	8.19	14.7	7.11	6	2
m	19.9	43.4	0.49	9.22	43.6	2.58	81.2	1.90	7.60	9.73	7.17	6	2
sx	14.9	26.6	0.58	20.2	20.9	1.43	43.9	0.71	4.58	11.2	0.45	2.55	0.81
vx	74.4	52.3	86.8	99.8	48.0	53.2	53.6	38.6	56.0	76.2	6.31	41.8	49.4
min	1.00	22.70	0.16	3.55	7.60	1.13	30.1	0.60	2.30	5.70	6.20	1	0
max	40.7	95.0	2.24	56.9	77.5	5.90	174	3.20	14.8	37.7	7.58	10	3
R	39.7	72.3	2.08	53.4	69.9	4.77	144	2.60	12.5	32.0	1.38	9	3
xg	–	–	0.52	–	–	–	–	–	–	12.0	7.11	5	–

	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}
n	11	11	11	11	11
x					
m					
sx					
vx					

	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}
min	0	0	0	0	0
max	15	15	106	380	0
R	15	15	106	380	
xg	2	6	10	17	
positive	5	4	3	1	0
% positive	45.5	36.4	27.3	9.1	0.0

	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
n	11	11	11	10	11	7	9	10	5
x				0.005	0.025		0.002	0.001	
m				0.005	0.025		0.001	0.001	
sx				0.003	0.023		0.002	0.001	
vx				62.5	90.9		89.2	80.2	
min	<0.04	<0.05	<0.1	0.001	0.001	<0.1	0.001	0.001	<0.001
max	<0.04	<0.05	<0.1	0.005	0.091	<0.1	0.006	0.003	<0.001
R				0.004	0.09		0.005	0.002	
xg									
positive	0	0	0	0	1	-	0	0	0
% positive	0	0	0	0	9.1	–	0	0	0

n x m: Hardness ** *($p < 0.01$)*, Mg * *($p < 0.05$)*, Ca ** ($p < 0.01$), Conductivity ** ($p < 0.01$)

LFA: o													
	NO_3^- mg L^{-1}	Cond. mS m^{-1}	COD mg L^{-1}	Cl^- mg L^{-1}	SO_4^{2-} mg L^{-1}	Hardness mmol L^{-1}	Ca mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	pH	Colour mg L^{-1}Pt	Turbidity ZF
n	6	6	6	6	4	6	5	3	5	5	6	6	6
x	16.6	32.0	0.54	12.2	37.9	1.90	63.6	1.47	7.46	14.9	7.18	7	1
m	17.7	30.6	0.57	8.81	39.9	2.24	76.2	1.40	7.30	3.65	7.27	6	1
sx	9.87	14.9	0.34	10.5	32.7	0.88	34.9	0.21	3.43	24.5	0.33	2.74	0.52
vx	59.3	46.6	62.2	86.2	86.2	46.5	54.9	14.2	46.0	165	4.57	42.1	38.7

LFA: o													
	NO_3^- mg L^{-1}	Cond. mS m^{-1}	COD mg L^{-1}	Cl^- mg L^{-1}	SO_4^{2-} mg L^{-1}	Hardness mmol L^{-1}	Ca mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	pH	Colour mg L^{-1}Pt	Turbidity ZF
min	4.49	12.6	0.16	2.13	0.63	0.63	19.2	1.30	3.40	1.80	6.53	5	1
max	32.3	50.6	0.98	29.1	71.2	2.67	96.2	1.70	12.7	58.5	7.40	12	2
R	27.8	38.0	0.82	27.0	70.6	2.04	77.0	0.40	9.30	56.7	0.87	7	1
xg													

	Coli. CFU $100mL^{-1}$	Enter. CFU $100mL^{-1}$	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU $100mL^{-1}$
n	6	3	6	6	3
x					
m					
sx					
vx					
min	0	0	2	12	0
max	30	70	66	448	11
R	30	70	64	436	11
xg	6	22	41	314	8
positive	5	3	2	2	3
% positive	83.3	50.0	33.3	33.3	50.0

	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
n	6	6	5	5	2	3	3	3	3
x				0.023	0.028		0.003	0.002	
m				0.021	0.025		0.003	0.001	
sx				0.021	0.021		0.002	0.001	
vx				91.8	73.5		72.1	88.2	
min	<0.04	<0.05	<0.1	0.001	0.001	<0.1	0.001	0.001	<0.001
max	0.27	<0.05	0.22	0.049	0.061	1.29	0.004	0.003	0.006
R				0.048	0.06		0.003	0.002	

	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
xg									
positive	0	0	1	0	1	–	0	0	0
% positive	0	0	20	0	20	–	0	0	0

III: *Organic and conventional farming comparison*

	organic												
	NO_3^- mg L^{-1}	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Cond. mS m^{-1}	COD mg L^{-1}	Cl^- mg L^{-1}	SO_4^{2-} mg L^{-1}	Hardness mmol L^{-1}	Ca mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	pH
n	12	12	12	12	12	12	11	12	7	12	12	6	12
x	10.5			20.1	0.47	6.56	23.9	1.13	17.3	1.35	8.22	12.32	7.30
m	6.97			14.2	0.41	3.73	23.3	0.80	19.2	1.35	5.15	6.08	7.39
sx	8.48			13.9	0.25	7.92	16.2	0.92	8.65	0.55	7.14	20.44	0.40
vx	80.6			69.2	52.8	121	68.1	81.1	50.0	40.8	86.8	165.9	5.44
min	1.63	<0.04	<0.05	6.70	0.16	0.71	0.63	0.40	5.70	0.50	2.20	1.70	6.53
max	28.0	0.31	0.81	50.6	1.07	29.1	58.6	3.30	28.1	2.50	22.4	58.5	8.00
R	26.4			43.9	0.91	28.4	58.0	2.90	22.4	2.00	20.2	56.8	1.47
normality	yes	no	no	yes	yes	no	yes	yes	yes	yes	yes	yes	yes
xg						3.85							
n positive	0	0	1	0	0	0	0	8	7	-	0	5	0
% positive	0	0	8.33	0	0	0	0	72.7	100		0	83.3	0

	Colour mg L^{-1}Pt	Turbidity ZF	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
n	12	12	12	12	12	12	12	12	12	12	12	10	8	9
x	10	2	10	17	48	107	7		0.01	0.05		0.003		0.003
m	6	1	2	0	12	34	0		0.01	0.01		0.003		0.002
sx	12.1	3.7							0.01	0.10		0.002		0.003
vx	123	165							119	206		67		94.6
min	5	1	0	0	0	0	0	<0.1	0.001	0.001	<0.1	0.001	<0.001	0.001

	Colour mg L^{-1}Pt	Turbidity ZF	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
max	48	14	46	120	304	500	46	1.75	0.05	0.35	0.56	0.01	0.011	0.01
R	43	13	46	120	304	500	46		0.05	0.35		0.01		0.01
normality	yes	yes	no	no	no	no	no		yes	yes		yes		yes
xg			8	50	102	321	25							
n positive	1	1	7	3	4	3	3	3	0	2	–	0	0	0
% positive	8.33	8.33	58.3	27.3	36.4	27.3	27.3	25.0	0	16.7	–	0	0	0

	conventional												
	NO_3^- mg L^{-1}	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Cond. mS m^{-1}	COD mg L^{-1}	Cl^- mg L^{-1}	SO_4^{2-} mg L^{-1}	Hardness mmol L^{-1}	Ca mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	pH
n	18	18	18	18	18	18	11	18	18	12	17	18	18
x	19.0			44.6	0.64	18.2	39.4	2.27	75.5	1.88	7.41	11.0	7.02
m	19.6			38.8	0.57	9.91	40.8	2.27	80.2	1.90	7.25	7.90	7.18
sx	12.9			25.0	0.48	18.8	22.9	1.33	40.8	0.63	4.71	10.28	0.51
vx	67.6			56.1	74.3	103	58.1	58.5	54.1	33.4	63.5	93.2	7.22
min	1.00	<0.04	<0.05	8.80	0.16	1.06	7.20	0.43	8.02	0.60	0.00	1.80	5.71
max	40.7	<0.04	<0.05	95.0	2.24	56.9	77.5	5.90	174	3.20	15.9	37.7	7.58
R	39.7			86.2	2.08	55.8	70.3	5.47	166	2.60	15.9	35.9	1.87
normality	yes			yes	no	yes	yes	yes	yes	yes	yes	yes	yes
xg					0.51								
n positive	0	0	0	0	0	0	0	10	11	–	0	12	2
% positive	0	0	0	0	0	0	0	55.6	61.1		0	66.7	11.1

	Colour mg L^{-1}Pt	Turbidity ZF	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
n	18	18	18	18	18	18	18	17	15	17	10	14	15	8
x	7	2	4	4	21	66	1		0.007	0.02		0.003		0.00063
m	6	2	2	0	11	19	0		0.005	0.03		0.002		0.001
sx	2.64	0.70							0.005	0.02		0.002		0.0002
vx	40.3	45.3							70.7	81.0		87.7		37.0

	Colour mg L^{-1}Pt	Turbidity ZF	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
min	1	0	0	0	0	0	0	<0.1	0.001	0.001	<0.1	0.001	<0.001	0.001
max	12	3	34	19	106	448	9	0.29	0.02	0.09	1.29	0.01	0.003	0.001
R	11	3	34	19	106	448	9		0.02	0.09		0.01		0.0005
normality	yes	yes	no	no	no	no	no		yes	yes		yes		no
xg			4	8	50	413	7							
n positive	0	0	11	7	5	2	2	1	0	1	–	0	0	0
% positive	0	0	61.1	38.9	27.8	11.1	11.1	5.88	0	5.88	–	0	0	0

organic x conventional: Hardness * *($p < 0.05$)*, Ca *** *($p < 0.001$)*, Cl^- * *($p < 0.05$)*

IV:. *Distribution according altitude*

Altitude < 350 m													
	NO_3^- mg L^{-1}	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Cond. mS m^{-1}	COD mg L^{-1}	Cl^- mg L^{-1}	SO_4^{2-} mg L^{-1}	Hardness mmol L^{-1}	Ca mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	pH
n	12	12	12	12	12	12	7	12	10	8	10	10	12
x	20.7			35.8	0.68	14.8	37.7	2.38	79.9	1.56	7.94	11.37	7.14
m	19.7			26.7	0.49	9.22	35.4	2.44	86.7	1.75	7.25	8.82	7.18
sx	13.1			22.7	0.58	16.29	20.9	1.45	45.9	0.44	5.90	9.96	0.29
vx	63.5			63.4	85.5	110	55.3	60.9	57.4	28.2	74.2	87.6	4.09
min	1.0	<0.04	<0.05	6.70	0.16	2.13	7.60	0.65	30.1	0.60	0.00	2.43	6.52
max	40.7	0.22	<0.05	88.5	2.24	56.9	71.2	5.90	174	1.90	22.4	37.7	7.58
R	39.7			81.8	2.08	54.8	63.6	5.25	144	1.30	22.4	35.3	1.06
normality	yes			yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
xg													
n positive	0	0	0	0	0	0	0	6	0	-	0	5	0
% positive	0	0	0	0	0	0	0	50	0		0	50	0

	Colour mg L^{-1}Pt	Turbidity ZF	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
n	12	12	12	12	12	12	12	11	10	11	7	8	9	5

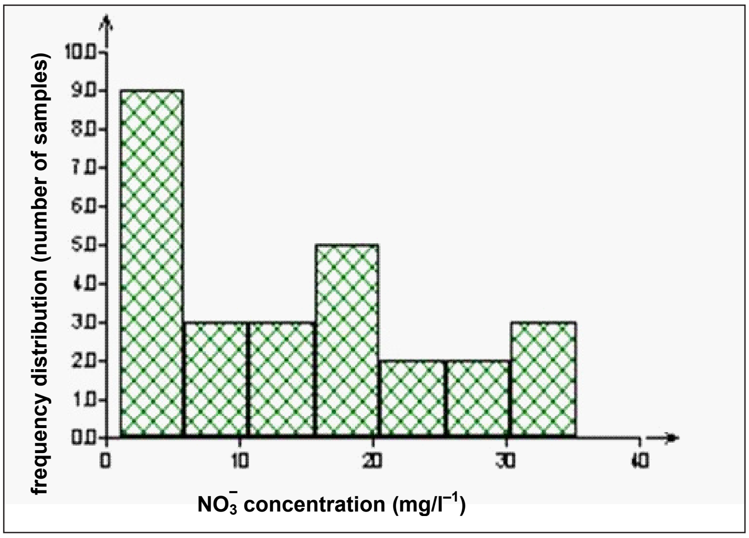
	Colour mg L⁻¹Pt	Turbidity ZF	Coli. CFU 100mL⁻¹	Enter. CFU 100mL⁻¹	MO 36 °C CFU mL⁻¹	MO 22 °C CFU mL⁻¹	E. coli CFU 100mL⁻¹	Fe mg L⁻¹	Cu mg L⁻¹	Mn mg L⁻¹	Zn mg L⁻¹	Pb mg L⁻¹	Cr mg L⁻¹	Ni mg L⁻¹
x	8	2							0.01	0.02		0.002		
m	6	2							0.005	0.03		0.002		
sx	2.39	0.62							0.01	0.01		0.001		
vx	31.9	35.5							87.33	43.83		74.4		
min	5	1	0	0	0	0	0	<0.1	0.001	0.001	<0.1	0.001	<0.001	<0.001
max	12	3	15	19	106	448	6	0.49	0.02	0.04	1.29	0.004	0.003	0.009
R	7	2	15	19	106	448	6		0.02	0.04		0.004		
normality	yes	yes	no	no	no	no			yes	yes		yes		
xg			3	7	46	413								
n positive	0	0	6	5	4	2	1	1	0	0	–	0	0	0
% positive	0	0	50	41.7	33.3	16.7	8.3	9.1	0	0		0	0	0

Altitude 350–450 m													
	NO_3^- mg L⁻¹	NO_2^- mg L⁻¹	NH_4^+ mg L⁻¹	Cond. mS m⁻¹	COD mg L⁻¹	Cl^- mg L⁻¹	SO_4^{2-} mg L⁻¹	Hardness mmol L⁻¹	Ca mg L⁻¹	K mg L⁻¹	Na mg L⁻¹	Mg mg L⁻¹	pH
n	10	10	10	10	10	110	7	10	7	8	10	7	10
x	14.8			41.3	0.56	18.8	34.8	1.83	58.4	1.98	8.98	17.9	7.04
m	14.0			34.7	0.49	9.56	31.7	1.77	76.2	1.85	7.5	6.08	7.22
sx	10.2			25.5	0.19	20.2	27.1	1.14	36.0	0.66	5.03	21.20	0.48
vx	69.0			61.9	34.5	108	78.0	62.1	61.7	33.3	56.1	118	6.86
min	1.29	<0.04	<0.05	12.2	0.16	1.77	0.63	0.45	11	1.3	3.1	1.8	6.2
max	33.4	0.27	0.07	95	0.82	56	77.5	4.15	108	3.2	15.9	58.5	7.5
R	32.1			82.8	0.66	54.2	76.9	3.7	97	1.9	12.8	56.7	1.3
normality	yes			yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
xg													
n positive	0	0	0	0	0	0	0	6	2	-	0	3	1
% positive	0	0	0	0	0	0	0	60.0	28.6		0	42.9	10

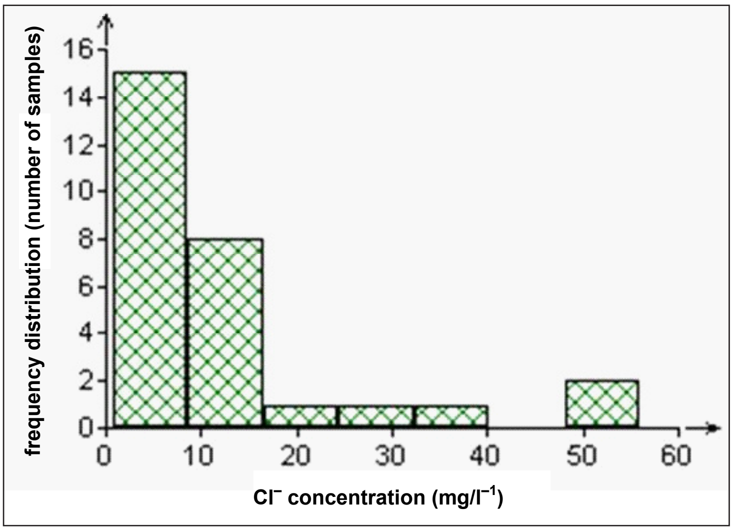
	Colour mg L^{-1}Pt	Turbidity ZF	Coli. CFU 100mL^{-1}	Enter. CFU 100mL^{-1}	MO 36 °C CFU mL^{-1}	MO 22 °C CFU mL^{-1}	E. coli CFU 100mL^{-1}	Fe mg L^{-1}	Cu mg L^{-1}	Mn mg L^{-1}	Zn mg L^{-1}	Pb mg L^{-1}	Cr mg L^{-1}	Ni mg L^{-1}
n	10	10	10	10	10	10	10	10	9	10	7	8	8	8
x	6	1							0.02	0.03		0.003		
m	5	1							0.0075	0.0175		0.002		
sx	2.32	0.63							0.02	0.03		0.003		
vx	42.2	52.7							114	106		92.9		
min	1	0	0	0	0	0	0	<0.1	0.001	0.004	<0.100	0.0005	<0.001	<0.001
max	10	2	46	70	304	500	46	0.29	0.049	0.091	0.27	0.007	0.001	0.006
R	9	2	46	70	304	500	46		0.048	0.087		0.0065		
normality	yes	yes	no	no	no	no	no		yes	yes		yes		
xg			5	20	142	332	17							
n positive	0	0	7	3	2	2	3	2	0	2	–	0	0	0
% positive	0	0	70	30	20	20	30	20	0	20		0	0	0

Altitude > 450 m													
	NO_3^- mg L^{-1}	NO_2^- mg L^{-1}	NH_4^+ mg L^{-1}	Cond. mS m^{-1}	COD mg L^{-1}	Cl^- mg L^{-1}	SO_4^{2-} mg L^{-1}	Hardness mmol L^{-1}	Ca mg L^{-1}	K mg L^{-1}	Na mg L^{-1}	Mg mg L^{-1}	pH
n	8	8	8	8	8	8	8	8	7	8	8	7	8
x	8.95			25.1	0.44	5.05	23.5	0.94	28.0	1.43	5.99	4.92	7.25
m	5.69			17.5	0.33	1.78	20.5	0.8	21.5	1.4	3.15	6.08	7.42
sx	9.30			24.8	0.26	5.71	13.7	0.74	31.8	0.64	6.71	1.96	0.70
vx	104			99.1	58.9	113	58.4	78.3	113	44.8	112	39.9	9.65
min	1.63	<0.04	<0.05	7.2	0.32	0.71	7.7	0.4	5.7	0.5	2.2	1.7	5.71
max	29.1	0.31	0.81	80.6	1.07	16.3	47.2	2.7	97.2	2.5	21.7	6.69	8
R	27.5			73.4	0.75	15.59	39.5	2.3	91.5	2	19.5	4.99	2.29
normality	yes			yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
xg													
n positive	0	0	1	0	0	0	0	6	4	-	0	6	1
% positive	0	0	12.5	0	0	0	0	75.0	57.1		0	85.7	12.5

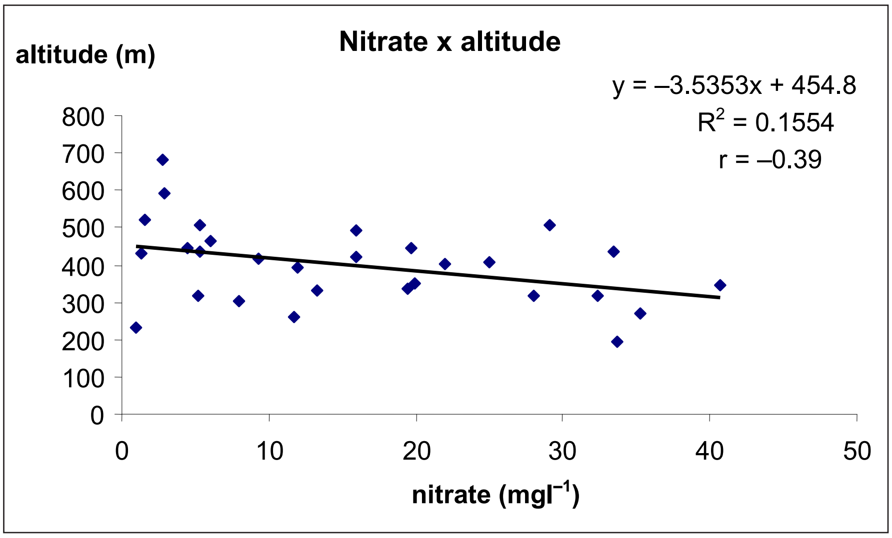
	Colour mg L⁻¹Pt	Turbidity ZF	Coli. CFU 100mL⁻¹	Enter. CFU 100mL⁻¹	MO 36 °C CFU mL⁻¹	MO 22 °C CFU mL⁻¹	E. coli CFU 100mL⁻¹	Fe mg L⁻¹	Cu mg L⁻¹	Mn mg L⁻¹	Zn mg L⁻¹	Pb mg L⁻¹	Cr mg L⁻¹	Ni mg L⁻¹
n	8	8	8	8	8	8	8	8	8	8	8	8	6	4
x	11	3							0.01	0.06		0.004		
m	6	1							0.01	0.019		0.004		
sx	14.8	4.56							0.004	0.13		0.002		
vx	130	166							52.5	199		46.0		
min	5	1	0	0	1	0	0	<0.1	0.002	0.003	<0.1	0.001	<0.001	0.001
max	48	14	35	120	90	300	30	1.75	0.012	0.35	0.56	0.006	0.011	0.006
R	43	13	35	120	89	300	30		0.01	0.35		0.005		
normality	yes	yes	no	no	no				yes	yes		yes		
xg			8	38	44									
n positive	1	1	4	2	3	1	1	1	1	1	–	0	0	0
% positive	12.5	12.5	50.0	25.0	37.5	12.5	12.5	12.5	12.5	12.5		0	0	0



1: *Nitrate content frequency distribution*



2: *Chloride content frequency distribution*



3: *The relationship between the nitrate content and the altitude*

It has not been proved that water quality of organic farms is higher than of conventional ones. It cannot be assumed that the farms producing milk in the lowlands, mostly in a conventional system, inspect water quality more than those in the mountains or in differently specific areas. There are statistically more organic farms at an altitude above 450 m than in the lowlands and there are also more LFAs in the mountains. Hardness content differences (Ca and Mg, too) are statistically significant in LFAs unlike the areas not included in LFA, in organic farms unlike the conventional managing ones. The hardness value (Ca, Mg) given by the regulation only serves as recommended and is defined as an optimal concentration from the health standpoint. The limiting values stated in the regulation are valid for waters, in which the Ca and Mg contents are reduced artificially during treatment. Some authors (Socha et al., 2003; Solomon et al., 1995) report that drinking water quality, and not only microbiological indicators, but also other parameters such as higher level of some anions, e.g. sulphates, nitrates and some metals in high concentrations, influences milk production. No excessive values have been found out. The microbiological exceeding of indicators can be eliminated by regular source disinfection along with control analysis execution. The dependence between an increasing altitude and a decreasing nitrate content pointing to a less intensive use of soil in the mountain areas was statistically significant.

SOUHRN

Vyhodnocení některých ukazatelů pitné vody ve vybraných, různě hospodařících chovech dojnic v České republice

Příspěvek hodnotí kvalitu pitné vody ve vybraných chovech dojnic na území České republiky. V dojírnách 30 farem byly odebrány vzorky pitné vody a následně proveden analytický rozbor. Byly stanoveny vytipované chemické a mikrobiologické ukazatele podle vyhlášky č. 252/2004 Sb. (pH, vodivost, chemická spotřeba kyslíku, barva, zákal, železo, amonné ionty, dusitany, dusičnany, počet kolonií rostoucích při 36 °C, počet kolonií rostoucích při 22 °C, koliformní bakterie, *Escherichia coli*, dále vápník, hořčík, sodík, draslík, zinek, měď, mangan, olovo, chrom a nikl). U získaného souboru dat bylo provedeno statistické vyhodnocení a získané údaje porovnány s mezními hodnotami danými vyhláškou. Obsah dusičnanů se pohyboval v rozmezí 1 až 40,7 mg/l s průměrem 15,6 mg/l, nejvyšší mezní hodnota dle vyhlášky je 50 mg/l. Hodnota pH kolísala od 5,71 do 8. Geometrický průměr koncentrace chloridů byl 7,57 mg/l. Průměrná koncentrace Ca 58,5 mg/l byla uvnitř vyhláškou doporučeného intervalu 40–80 mg/l. Geometrický průměr obsahu hořčíku 7,9 mg/l byl pod doporučenou hodnotou 20–30 mg/l. Limitní hodnoty pro Cu, Pb, Cr and Ni nebyly překročeny. Naopak limitní hodnota (0 KTJ/100 ml) byla překročena 18x u ukazatele koliformní bakterie, 10× u enterokoků (0 KTJ/100 ml), 5× u *Escherichia coli* (0 KTJ/100 ml). Počty kolonií rostoucích při 36 °C překročily limit 9× (20 KTJ/ ml), počty kolonií rostoucích při 22 °C (200 KTJ/ml) 5×.

V práci jsou dále srovnány rozdíly mezi ekologickými a konvenčními chovy, farmami podnikajících v různých typech LFA oblastí a farmami do těchto oblastí nezařazených. Diference zjištěná mezi koncentrací chloridů v ekologických (6,56 mg/l) a konvenčních chovech (18,2 mg/l; $p < 0,05$) byla statisticky významná. Dalším třídícím kritériem byla lokalita, resp. nadmořská výška, ve které daná farma leží. V nadmořské výšce nad 450 m n. m. je statisticky více ekologických farem než v nížinách a na horách je také více LFA oblastí. Byla zjištěna významná závislost ($p < 0,05$) pouze u obsahu dusičnanů, kdy se stoupající nadmořskou výškou klesal jejich obsah (korelační koeficient v hodnotě – 0,39). Toto zjištění naznačuje méně intenzivní využívání půdy v horských oblastech. Statisticky významné rozdíly byly u všech srovnávaných kritérií zjištěny u hodnoty tvrdosti a s tím souvisejícím obsahem vápníku a hořčíku. Byl zjištěn významný rozdíl v tvrdosti vody mezi oblastmi s nadmořskou výškou menší jak 350 (2,38 mmol/l) a větší jak 450 m n. m. (0,94 mmol/l; $p < 0,05$). Dle příslušné vyhlášky se však jedná jen o doplňkový ukazatel. Mezi hodnotami mikrobiologických nálezů v žádném případě nebyla zjištěna statistická průkaznost.

pitná voda, farma, kráva, mikrobiologická kvalita, chemické složení, studna, dezinfekce, LFA, konvenční způsob hospodaření, ekologický způsob hospodaření

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