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Arsenic Soil Contamination from Poultry Farm Waste Material

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Abstract

Agriculture has a strong environmental impact in terms of potential soil and water pollution. Poultry production is a significant branch of livestock production in the Republic of Croatia, and because of the increased need for food production, the production process is constantly intensified, which involves various manipulations in order to maximize yield. The main goal of this paper is to examine the presence of arsenic in the environment as a direct consequence of the disposal of poultry farm waste. Specifically, there has been a trend of increasing arsenic concentration in the soil, which is related to the use of roxarson, the most famous growth promoter and a pigmentation agent in the poultry industry, containing arsenic. More recently, emphasis has been placed on research for the consequences of its use. In this paper, soil arsenic content was investigated in one part of Varaždin County in the immediate vicinity of a poultry farm. Sampling locations were selected so that all tests would be performed on the same soil type and that the difference in arsenic content could be interpreted and matched to different levels of contamination from farm waste, that is, chicken manure.

Keywords: *Arsenic; Roxarson; Poultry Farm; Nitrate Nitrogen; Soil*

Introduction

In the last few years, according to the Statistical Yearbook of the Republic of Croatia from 2017, poultry meat has been leading the consumption of all types of meat [1]. This is due to various factors, among others, the short fattening time, the excellent utilized breeding space, the large reproductive capacity of poultry, the nutritional value of the meat and the certainly relatively low selling price of chicken meat.

It is well known that the environmental impact of agriculture is reflected in soil, water and air pollution [2-4]. Global production of poultry meat has increased rapidly over the last 50 years, growing more than 12-fold between 1961 - 2014 [5,6]. In the period from 2012 to 2018, Croatia recorded a 9% increase in production of poultry [7-9]. It is usually considered that in intensive rearing chickens fattening lasts up to 42 days. Due to the need for rapid fattening of chickens for slaughter, foods must be rich in feeds such as carbohydrates, fats, proteins, vitamins and minerals [10]. However, on the other hand, in the rearing of animals on industrialized farms, medicaments are used which cause residues of pharmacological substances that are potentially harmful to human health later on in animal feed [11]. It is well known that different sorts of veterinary drugs are used with food-producing animals. That has great potential to generate residues in food products (meat, eggs, milk...) and that presents a health hazard to the people which consume it. The drug residue can cause hypersensitivity reaction, development of antimicrobial drug resistance, mutagenicity, carcinogenicity, teratogenicity, and disruption of intestinal normal flora [12]. Likewise, the intensive use of pharmaceuticals is a growing burden on the environment. Consumption of pharmaceuticals for human and veterinary use is ascending as is their release into the environment. Two thirds of pharmaceuticals are used for veterinary purposes in the form of growth promoters, antibiotics and antiparasitic. They end up in the environment due to

inadequate treatment of municipal wastewater, leachate of farm animals and through animal excretions (fertilizers), which ultimately end up in soil and water after disposal on agricultural land [13-18].

Poultry production has been present in Varaždin County for over 60 years and represents the dominant agricultural production in this region. In 2002, there were 26 official farms registered in the county, excluding small family farms. On average, 78% of farms in Croatia do not have adequate housing for manure, which is a major problem of environmental pollution [19,20]. In the Republic of Croatia, poultry manure accounts for only about 3% of total manure produced, and in Varaždin County for over 15% [21]. The manure contains high concentrations of nitrogen and is therefore taken care of in such a way that it is spread on agricultural land and used in food production as a useful material [22,23]. The manure may also contain other harmful substances, including arsenic if poultry consume roxarson or other arsenic-rich compounds [24]. For example, one study has proven the total As concentrations in the poultry litter varied from 1 to 39 mg/kg, averaging 16 mg/kg [25]. The subject of the study in this paper is arsenic contained in poultry nutrition, potentially in the growth promoter roxarson, which has been used extensively in the United States (USA) and Europe [26].

In June 2011, at the request of the US Food and Drug Administration (FDA), the pharmaceutical industry Pfizer suspended the sale of 3-Nitro, also known as roxarson in the US [27], continued to sell Histostat until 2015. Histostat is also known as nitarson, and in chemical composition it is similar to roxarson. Currently, the use of organo-arsenic in the livestock industry is prohibited in developed countries, but the consequences of their use today can be detected in soil and water by chemical methods such as liquid chromatography and mass spectrometry.

Aim of the Study

The aim of this paper is to investigate the contamination of soil by arsenic from waste material from poultry farms in a specific area of Varaždin County.

Materials and Methods

Research area

The research was done in the central part of Varaždin County, which is located in the northwestern part of the Republic of Croatia. In the County the most registered farms belong to pig farms, followed immediately by poultry farms. The samples for this study were located near one poultry farm (46°10' 54'' N, 16°21'23'' E), in the area of lower pont geologic age, where mostly well- stratified sandy marls and loosely bound siltites are represented, within which sand and sandstone layers are observed. Sediment color is yellowish gray, gray and brown [28].

View existing data

Roxarson

Roxarson is an arsenic compound of 3-nitro-4-hydroxyphenylarsonic acid. It does not naturally occur in the soil, but its presence is due to its extensive use in the poultry industry as a promoter of growth. In developing countries, China and India, it is one of the most commonly used organo-arsenic additives in food that promotes growth, controls intestinal parasites and highlights pigmentation of poultry meat [29,30]. In the tissues of poultry consuming roxarson, the concentration of roxarson ranged from about 14 - 54 mg/kg, while in the manure various metabolites were present: arsenate (V), arsenite (III), monomethylarsonic acid (MMAA), dimethylsaric acid (DMAA) , 3-amino-4-hydroxyphenylarsonic acid and 4-hydroxyphenylarsonic acid [31].

Most roxarson consumed is excreted from chickens unchanged. Under conditions of storage of poultry farm waste, roxarson is susceptible to bacterial degradation resulting in conversion to inorganic arsenic [32]. Inorganic forms of arsenic are most common in

groundwater. They are easily adsorbed onto the roots and fruits of plants and ultimately question food security, all of which are due to the use of poultry manure as fertilizer for agricultural land [33]. In 1944, Roxarson was approved by the United States Food and Drug Administration (FDA) to treat coccidiosis (common poultry disease) and to achieve the desired weight and improve pigmentation of meat as quickly as possible. In 2010, industry representatives estimated that 88% of chickens received roxarson [34]. Due to the large quantities of roxarson used in the livestock and poultry industries and the potential effects of arsenic on humans and the environment, there has been an increasing interest in testing the effects of roxarson. Chronic arsenic exposure has been found to cause various types of cancer, cardiovascular disease, etc [35]. In 2011, the FDA noted increased concentrations of arsenic in the liver of chickens fed roxarson. To reduce arsenic buildup in chicken tissue, the FDA required a five-day withdrawal of roxarson before slaughter itself. Finally, in July 2011, in response to a safety assessment, the FDA suspended the sale of roxarson in the United States. However, the use of roxarson and other organ arsenics continues in other countries until February 2015.

Food is indispensable for the life of every organism because it provides input for the substances needed for metabolism. Likewise, a variety of harmful substances can be found in food that can adversely affect the health of humans and other organisms. A plant that grows on clean soil is suitable for all common uses and is harmless to any consumer, but otherwise, if soil is contaminated through it, the plant can be contaminated, especially if the soil pollutant is present in a chemical form in which the plant can absorb. The concentration of heavy metals in a plant depends on the type of plant, the concentration and availability of the element in the soil, the distance from the source of the emission, the season and weather [36]. Given their toxicity, excessive accumulation of heavy metals in plants can ultimately be detrimental to consumers.

Soil microorganisms have significant potential for the degradation of roxarson, but also after the consumption of roxarson there is a change in the composition and structure of the microorganisms and a decrease in microbial diversity. Some bacteria inhibit roxarson while some play a very important role in its breakdown [37].

The transfer of the roxarson metabolite from soil to the edible parts of the plant is a key step in its entry into the human food chain. In China, the regular dose of roxarson in poultry feed is 25 to 50 mg/kg [38]. Roxarson is retained in the animal for a short time and is excreted unchanged and can degrade into more toxic metabolites after composting. Methylated forms monomethylarsin (MMA) and dimethylarsin (DMA) can cause tumors in the skin, lungs, liver, kidney, thyroid, bladder, lymph nodes in animals and humans [39]. Likewise, according to studies, 70 - 90% of arsenic in poultry manure is water soluble [40]. Animal manure is usually applied as an organic fertilizer. Therefore, the bioavailability of roxarson and its metabolites in manure is high, so it is not surprising the general concern that caused the withdrawal of roxarson from the market, as well as continued research into the consequences of its long-term use.

Arsenic

Arsenic is a metalloid that occurs in various organic and inorganic forms. It is widely distributed in the environment as a result of natural and anthropogenic activity. It occurs naturally in four oxidation states such as arsine, arsenic, arsenite and arsenate. Arsenic can enter the food chain causing widespread distribution in plant and animal species [14-16]. Arsenic and its compounds are relatively mobile in the environment. Depending on the geological, climatic and hydrological condition, soil and sediments, surface water, groundwater and air can be enriched with arsenic [41].

The average arsenic content in unpolluted soil is about 5 mg/kg [42]. Increased concentrations of arsenic were registered in the valleys of the Drava and Mura rivers and in the area between Molvi and Kalinovci, where the maximum concentration was measured in northern Croatia. The measured concentrations of arsenic in the soil in the wider Podravina area range between 0.5 and 92 mg/kg with a median value of 10 mg/kg [43]. In nature, arsenic can be found in as many as 245 different minerals (sulfides, sulfosols, arsenides, but also oxides, arsenites and arsenates). Arsenic toxicity depends on the chemical form in which it is present. Inorganic arsenic, arsenite As (III) and

arsenate As (V), are more toxic and more common than organic ones and easily bind to clay minerals [31]. The speciation of inorganic arsenic depends on the pH value and redox potential. Arsenate and arsenite are adsorbed on the surfaces of various alluvial materials such as iron oxide, aluminum oxide and clay minerals.

The mineral forms in which arsenic may be present in the soil are 60% arsenic and 20% sulfides and sulfate salts, the remainder includes 20% arsenide, arsenite, oxide, silicates and elemental arsenic. Such mineral forms, over time, pass into water-soluble inorganic arsenic species. In aqueous solutions, arsenic is present in the form of arsenic and arsenic acid oxoanions, which under anaerobic conditions can be methylated by bacteria, yeasts or fungi, and produce organic components: monomethyl sulfuric acid (MMAA), dimethyl sulfuric acid (DMAA), and gaseous arsenic derivatives, such as arsenic. DMA and trimethyl arsine (TMA). Under aerobic conditions, the oxidation of methylated components occurs in inorganic spices [44].

Sampling

For the research, 5 samples were collected in the Varaždin County area (Figure 1). The first soil sample (T1) was taken in a meadow that was never fertilized with chicken manure and represented a zero state. The second sample (T2) was taken from the farm directly below the waste material disposal area. The farm is of a somewhat older date and has no arranged landfill for manure, but all waste material is deposited in the immediate vicinity of the farm on manure pile. The third sample (T3) is from a garden that has been regularly fertilized by the manure of a nearby farm over many years. The fourth sample (T4) was taken from a plow on which the manure was stored at rest for a minimum of two years. The fifth sample is pure chicken manure from a resting pile (T5). Samples were taken with a shovel at a depth of 0 - 30 cm after the removal of vegetation and the organic layer. After sampling, the samples were transported to the Laboratory for Environmental Geochemistry, Faculty of Geotechnical Engineering, University of Zagreb, in Varaždin.

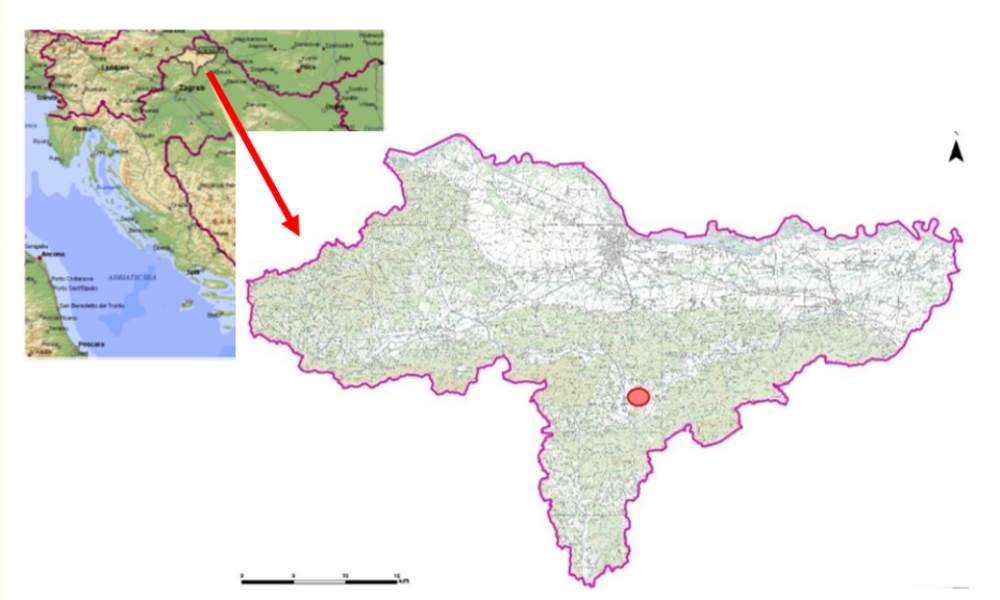

Figure 1: *Location of the Varaždin County in the Republic of Croatia and a topographic map of the county with the indicated research area.*

Laboratory analysis of samples

During the preparation of the samples for analysis, soil samples were air-dried to prevent loss of volatile elements. The samples thus dried were manually ground and sieved through 2 mm mesh sieves to obtain a fraction of less than 2 mm. The samples thus prepared were analyzed for pH_V, pH_{KCl}, soil anions (nitrite, nitrate and ammonia), dissolved organic carbon (DOC) and arsenic. Arsenic was analyzed by the aqua regia extraction method. In a 50 mL beaker, 2g of ground and sifted air-dried soil sample was weighed and an aqua regia was added to the sample in a ratio of HCl : HNO_3 = 3 : 1, more specifically 5 mL of nitric acid (HNO_3) and 15 mL of hydrochloric acid (HCl). The beakers were sealed with parafilm and the samples were digested in a 50°C water bath for 6 hours. After cooling, the samples were filtered and diluted with deionized water to 50 mL. Since, according to data from the Geochemical Atlas of Croatia, the extractability of arsenic with a solute is 96.3%, it is an appropriate method of obtaining the total concentration of arsenic in soil and manure samples [43]. The arsenic concentrations were measured on the AAnalyst 800 Atomic Absorption Spectrometer from Perkin Elmer on the samples thus prepared. Before the sample was taken, the device was calibrated with standard solutions of known concentrations. Standards were prepared by diluting a certified reference solution of 1000 mg/L As by Perkin Elmer with the addition of 0.1% Pd + 0.06% $Mg(NO_3)_2$ as the matrix modifier. Deionized water (0.05 μS/cm, pH 6.9, Direct-Q3, Millipore, USA) was used for all analyzes. All standards and samples were recorded 3 times and the results were expressed as the mean of 3 measurements [45]. Aqueous eluates were prepared to determine the anions in the soil. 50g of soil and 125 ml of deionized water were placed in an Erlenmeyer flask. The samples were mixed with an orbital mixer for two hours. They were then centrifuged in Centric 322A by Tehnica at 3500 rpm for 15 minutes. The eluates were then filtered through a 0.45 μm Sartorius filter with a pore diameter to remove any particles that remained suspended in the solution. On the prepared samples, nitrate, nitrite, ammonia concentrations were measured on a HACH LANGE DR5000 spectrophotometer and dissolved organic carbon was measured on a TOC/TN device from SHIMADZU [46].

Results

pH of the soil

The value of ion concentration in a sample depends on various soil processes such as sorption, precipitation, hydrolysis, and reduction-oxidation processes. Knowledge of soil pH is very important in determining the main characteristics of soil, since soil pH affects the solubility and availability of many elements as well as microbial activity. In addition, knowing the pH of the soil gives insight into the chemical processes taking place in the soil. The degree of acidity affects the physical, chemical and biological properties of the soil, i.e. the chemical wear of minerals, the formation of secondary minerals, the process of humification, the mobility of nutrients, the activation of ecologically active elements [47].

The measured pHv values of the samples varied in the range of 7.40 to 8.10 (Figure 2a). pH_{KCl} variable acidity values range from 6.46 to 7.62. According to Thun [48] the soils are slightly alkaline which means that the conditions are favorable for the deposition of Mg and Ca carbonates. The T5 manure sample has a pH value of 6.46 which is within the literature values for chicken manure (6 - 8) [49]. Based on the measured pH_V and pH_{KCl} values, the so-called "salt effect" is calculated according to the expression: $\Delta pH = pH_{KCl} - pH_V$.

Positive values of ΔpH represent the medium with positively charged particles and colloids, while negative values represent the medium with negatively charged particles and colloids.

Tested soil samples in a part of Varaždin County show a negative value of ΔpH, which means that negatively charged particles with a good positive ion binding capacity such as e.g. NH_4^+.

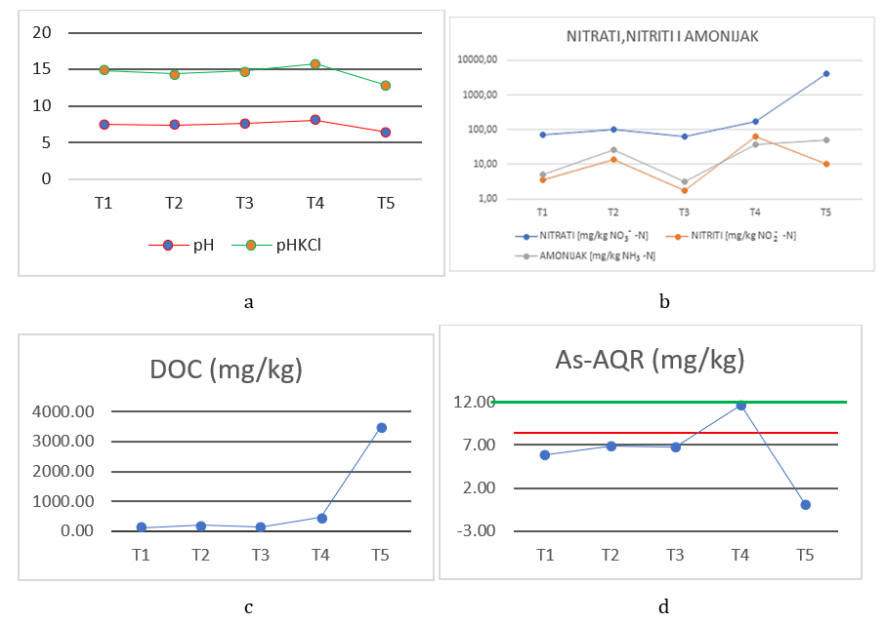

Figure 2: *a) pHV and pHKCl values of soil water eluate samples. b) Nitrates, nitrites and ammonia in aqueous soil eluate. c) Dissolved organic carbon values in aqueous soil eluate. d) Measured values of arsenic.*

Ammonia (NH3), nitrates (NO3-), nitrites (NO2-)

Today, in conventional agriculture, nitrate nitrogen is imperative for success and high yields. However, due to the increased use of artificial and mineral fertilizers, the disposal of animal waste and more intensive agricultural production, a large amount of nitric nitrogen reaches the environment each year. In the last few years, nitrate nitrogen has become a subject of research, which ultimately resulted in the adoption of the Nitrate Directive [50]. Sample T1 contains low concentrations of all nitrogen forms, nitrates, nitrites and ammonia as seen in figure 2b. The sample was taken in a meadow not fertilized by chicken manure, but one of the plant species present is clover, a plant whose roots contain nitrifying bacteria that allow it to use elemental nitrogen from the air. In addition to clover living in symbiosis with nitrifying bacteria, nitrogen from the atmosphere can bind free-living heterotrophic bacteria and free-living photoautotrophic bacteria. The most famous aerobic nitrogen fixers are *Azotobacter*, *Azospirillum* and *Beijerinckia* with multiple species [51]. Also, nitrogen returns to the soil by rotting plants and animals.

The aqueous eluate of sample T3, taken from a garden regularly fertilized with chicken manure, contains the lowest concentrations of nitrate, nitrite and ammonia. This may be due to the fact that the sample was taken at the time of intensive vegetation while the plants need significant amounts of nitric nitrogen for growth and development. Nitrogen is involved in protein building and important constituents of the cell nucleus and protoplasm. The recommendation of agrotechnical measures is that nitrogen is introduced repeatedly during the growing season, since it cannot be kept in the soil for a long time and is constantly needed by the plant. If nitrogen is not introduced into the soil either by fertilizers or by rotting of plants and animals (e.g. mulching), its concentration will decrease over time.

Significant concentrations of nitrates, nitrites and ammonia were observed in soil samples T2 and T4. Figure 3 shows the ratio of nitrate, nitrite and ammonium content for each sample. It is evident that samples T2 and T4 have a higher relative ammonia content.

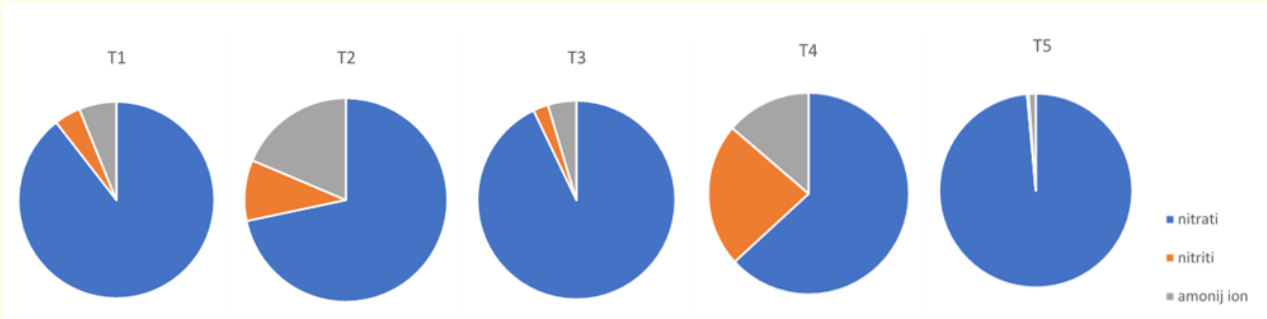

Figure 3: *Nitrate, nitrite and ammonium ion content of the samples.*

With the decomposition of organic matter, the organic compounds of nitrogen are transformed to ammonia by the process of ammonification. Through the nitrification process, ammonia oxidation produces nitrites and then nitrates. Since in T2 and T4 samples organic matter was exposed to ammonification processes for a longer period, this result was to be expected. Ammonia is very water soluble and binds to clay minerals since it has a positive charge of NH_4^+.

Also, it is evident that a significantly higher content of nitrite in the T4 sample compared to other samples means that all the processes of the circular cycle of nitrogen in nature have had time to occur and are in balance and not consumed by the plants. This would mean that such sites, in the case of well-permeable deposits, are ideal sites for the passage of nitrogen to groundwater. Almost 98% of the nitrogen in the T5 sample is in the form of nitrate, which means that such deposited manure is "ripe" and is best suited for use on agricultural land since such nitrogen is readily available to the plant and can be used to its fullest potential.

Dissolved organic carbon (DOC)

Chicken manure contains a large amount of organic carbon whose concentration decreases with the aging of the manure itself. In addition to the poultry droppings themselves, manure often contains residues of litter (sawdust), which is a poorly degradable material.

Soil organic matter is a mixture of humic and fulvic acids and non-humic components containing carbohydrates, proteins and fatty acids. Humic and fulvic acids have a wide range of functional groups whose metal binding ability can vary greatly. The influence of organic matter on the mobility of metals depends on the properties of the organic matter, the degree of huminification, the relationship between the soluble organic acids of low molecular weight acting as carriers of the metal and the components of high molecular weight that retain the metals. Under alkaline conditions, the organic matter can decompose and the metals attached to it become mobile, while under acidic conditions, the protonation of the organic matter surface leads to a loss of negative surface charge and the ability to adsorb cations [52].

DOC is used for the purpose of estimating pollution levels because soil DOC concentrations are very well correlated with organic impurities [53]. The obtained values of the tested samples range from 125.8 to 3462.5 mg/kg (Figure 2c). The highest DOC concentration was measured in the T5 sample. The concentration of organic carbon in the manure decreases [54]. First, readily degradable compounds (simple sugars, starch, fats and proteins) are broken down, and then slowly degradable such as cellulose and hemicellulose [55]. Sample T4 has a higher concentration of DOC than sample T3 since the manure pile above that soil is stored longer and the leaching of organic matter is longer. The sample taken in the meadow has the lowest DOC concentration since there is no other way of introducing organic matter into the soil at this location, apart from the decomposition of the plant material.

Arsenic

The village of Ključ is located in the border area between Podravina and northern Croatia. The average value of arsenic in the surface part of the soil for Podravina is 8.4 mg/kg and for the area around Ključ it is 8 to 12 mg/kg [43]. Arsenic concentrations in soils of northern Croatia range from 1.8 to 52.7 mg/kg with an average value of 10 mg kg [56].

The measured concentrations of arsenic obtained after the extraction with a solute are in the range of 5.81 mg/kg to 11.62 mg/kg in soil and 0.05 mg/kg in manure.

Figure 2d shows that sample T4 has an arsenic concentration higher than the average value for Podravina (red line) and Northern Croatia (green line) according to the Geochemical Atlas of Croatia [43]. This may be due to the long-term leaching of arsenic from the poultry farm manure. In samples T2 and T3 the arsenic concentrations are slightly higher than in the T1 meadow sample. This can be attributed to the processes of leaching of arsenic from soil to groundwater since arsenic is in alkaline soil in the forms of $H_2AsO_4^-$ or $HA_sO_4^{2-}$, which are mobile in soils with predominantly negatively charged particles. The major form of arsenite As (III) below pH 9.3 is $H_3AsO_3^0$ [52]. The lowest arsenic concentration is in the T5 chicken manure sample. Since roxarson has not been used in chicken farming since 2015, elevated concentrations of arsenic in soil under older manure could be the result of years of practice in using this dangerous compound in poultry, the effects of which are still felt today. The measured values of arsenic in the aqueous eluate represent the water-soluble fraction of this element that is most easily and rapidly mobilized by precipitation. Concentrations measured in the aqueous soil eluate range from 0.00593 to 0.067 mg/kg. The lowest concentration of arsenic is found in the T5 manure sample, which is the result of the discontinuation of roxarson as a promoter of poultry growth. Sample T4 soil under manure two years old has the highest arsenic concentration.

A comparison of the concentrations of arsenic obtained by the aqua regia method and the concentrations of arsenic in the aqueous soil eluate shows that only one small percentage of arsenic (0.18 to 0.77%) is easily mobile. Most arsenic was mobilized from manure (as much as 11%), although its concentrations in manure were lowest. This is in favor of stopping the use of roxarson in chicken production since manure arsenic can be mobilized extremely quickly, easily and at high concentrations, thereby reaching water and soil.

Part of arsenic can also be bound to organic matter, as can be seen in figure 4, where for samples T1-T4 with increasing concentration of organic matter there is also an increase in arsenic concentration

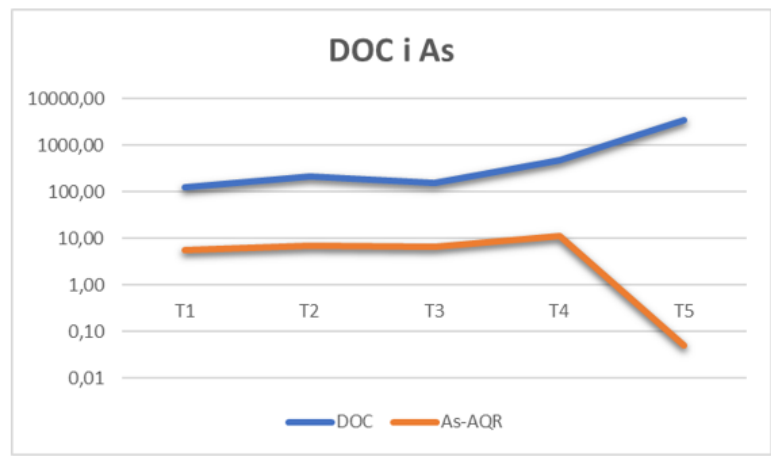

Figure 4: *Comparison between measured DOC and arsenic content in individual samples.*

Discussion

Today, much attention is paid to preserving soil and groundwater quality. The impact of agriculture is strongly recognized in the environment in terms of potential soil and water pollution. Poultry production is a significant branch of livestock production in the Republic of Croatia and, due to the increased need for food, production is intensified with the aim of increasing yields. In Varaždin County, small and medium-sized poultry farms and lower standards for manure management are prevalent compared to large farms. In the poultry industry, until 2015, the chemical compound roxarson containing arsenic was used as a promoter of poultry growth in Europe. Waste material from poultry farm have significant impact on water and soil per se, and a more significant burden is if additional harmful additives are added to the poultry diet. As part of this work, soil and chicken manure samples were tested to determine arsenic soil load from poultry farm waste. In addition to the concentration of arsenic, pH_V, pH_{KCl}, DOC and concentrations of nitrates, nitrites and ammonium ions were measured on the samples.

According to the obtained results, the pH shows that it is a slightly alkaline soil. Also, soil testing shows a negative value of ΔpH, which means that negatively charged particles with a good binding capacity of positively charged ions, as in this case NH_4^+ ammonium, prevail in the soil.

The obtained concentrations of nitrates, nitrites and ammonium ions are in accordance with the degree of loading of waste material from the farm. This means that soil fertilized with chicken manure showed low values of nitrogen concentrations, while samples below the stored manure were rich in nitrogen. The highest concentration of DOC was measured in the T5 sample of pure manure, while the highest concentration of soil samples had the T4 sample taken from the field where the manure was stored for two years.

It is important to note that, for this work, samples were taken in a very narrow area of distribution and the results and conclusions refer exclusively to the area tested. In the near future, it would be good to extend research to other areas of Varaždin County, especially to parts with different types of surface deposits and different levels of load on poultry farm waste so that a wider picture of the situation can be obtained. Research should certainly cover farms with an older date of production and the location of their landfill. Only then could more concrete conclusions be reached as to whether and how much did roxarson affect the quality of soil and groundwater in Varaždin County and beyond.

Conclusion

The concentrations of total arsenic in soil samples T1, T2 and T3 are within the range of usual concentrations for the study area according to the Geochemical Atlas of Croatia. However, in the soil sample T4, the concentration of arsenic is much higher than in other samples, which can be interpreted by the long-term leaching of arsenic from poultry waste. A very low concentration of arsenic was measured in the manure sample, confirming the discontinuation of roxarson and other arsenic-containing substances in its composition. The results of this study showed that arsenic was not contaminated with arsenic from poultry farm waste in this area. If the poultry industry continued to consume these preparations, the consequences would certainly be serious, but in today's situation when they are banned, there is no cause for concern.

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