Orginal paper
Received: 03.04.2024 UDK 628.3:637.5
Acceptance: 08.04.2024. DOI 10.7251/SVR2428037M

# ENVIRONMENTAL BENEFITS OF THE INTRODUCTION AND IMPLEMENTATION OF ISO 14001 STANDARD IN THE MEAT INDUSTRY EXPRESSED THROUGH THE CONCENTRATIONS OF NITROGEN COMPOUNDS IN WASTEWATER

**Faris Muminović**[1],
**Slobodanka Pavlović**[2],
**Halid Makić**[3],

**Abstract:**

The nitrogen compounds that were the subject of research are as follows: nitrate nitrogen ($NO_3$-N), ammonia nitrogen ($NH_4$-N) and total nitrogen (N). The values of the mentioned parameters were monitored before the introduction and implementation of the ISO 14001 standard (period January-June) and after the introduction and implementation (period July-December). The values of nitrate nitrogen ($NO_3$-N), ammonia nitrogen ($NH_4$-N) and total nitrogen (N) are expressed in mg/l (their minimum and maximum values) with the associated limit values. Also, the average values of concentrations of nitrogenous compounds (Me, mg/l) with standard deviations (SD, mg/l) and errors of average assessment (SE, mg/l) were recorded. The daily load of wastewater with total nitrogen per day, as well as the equivalent of harm from total nitrogen expressed in the equivalent number of inhabitants, were the subject of calculations. Before the aforementioned calculations, the calculation of deviations from the limit values was started. The obtained results of the evaluation of the equivalent of harm were processed with a t-test (comparison before and after the introduction and implementation of the

1 Faris Muminović, master's degree in sustainable food production systems Company: AC Food d.o.o., Head of the quality control, standardization and development department, e-mail: faris.muminovic@acfood.ba

2 Slobodanka Pavlović, Associate professor, Doctor of Science in the field of environmental protection, Faculty of Applied Ecology "Futura", Metropolitan University, e-mail: boba.pavlovic@gmail.com; Belgrade, Serbia

3 Halid Makić, doctor of biotechnological sciences, Faculty of Biotechnology, University of Bihać, Full professor, e-mail: halidmakicbtf@gmail.com,Bihać, Bosnia and Herzegovina

ISO 14001 standard). The daily load of wastewater with ammonia nitrogen and nitrate nitrogen was calculated taking into account the average values of the concentrations of the mentioned compounds and the daily flow, and before that, the calculation of deviations from the limit values was started. The T-test was used to compare the harmfulness of the mentioned compounds before and after the introduction and implementation of the ISO 14001 standard. The Mann-Whitney U test was used to test the average values of the median daily load of ammonia and nitrate nitrogen. The hypotheses were also tested: the distribution of the daily load of wastewater with ammonia nitrogen is the same before and after the introduction of the ISO 14001 standard, and the distribution of the daily load of wastewater with nitrate nitrogen is the same before and after the introduction of the ISO 14001 standard.

***Keywords:*** *ISO 14001, nitrogen compounds, average values, harm equivalent, daily wastewater load, t-test, Mann-Whitney U test*

**JEL classification: Q53**

## INTRODUCTION

Every sector of our society generates waste: industry, agriculture, mining, energy, transportation, construction, and consumers. The environment can only absorb a limited amount of pollutants and if they are found above this critical limit, pollution is inevitable. Industrial wastes are generated from different processes, and the amount and toxicity vary with its specific industrial processes (Shen, 1995).The meat industry is one of the food industries with a global environmental impact. This type of production affects climate change in relation to global warming, generates substances that deplete the ozone layer, and is characterized by high water and energy consumption, which leads to the discharge of waste and wastewater (Kuzlyakina et al., 2019).The subject of the research was the concentration of nitrogen compounds in the wastewater of the meat industry, monitored before and after the introduction and implementation of the ISO 14001 standard. Lower concentrations of nitrogen compounds were taken as the target value after the introduction and implementation of the standard. Daily loads of wastewater with nitrogen compounds and the equivalent of harm from them (environmental harm) were monitored. The t-test was used to compare the harmfulness of nitrogenous compounds before and after the introduction and implementation of the standard. This test is a ratio that quantifies how significant the difference is between the 'means' of two groups while taking their variance or distribution into account (Wadhwa & Marappa-Ganeshan,2024). The Mann-Whitney U test was used to test hypotheses in the domain of distribution of the daily load of wastewater with ammonia and nitrate nitrogen. The structure

of this paper consists of the following units: the importance of the ISO 14001 standard, the average values of nitrogen compounds before and after the introduction and implementation of ISO 14001, environmental damage from nitrate nitrogen, total ammonia nitrogen and total nitrogen.

## 1. WORK METHODOLOGY

The methodological approach involved monitoring the concentrations of nitrogen compounds before and after introducing and implementing the ISO 14001 standard, which was accompanied by statistical analysis. Sampling, as well as wastewater testing, was carried out in the authorized laboratory of Herkon d.o.o. Mostar. Wastewater was sampled at the location of the company, meat industry, MS-ALEM d.o.o. Bosanska Krupa.The potentially polluted area was represented by a stream. The place of sampling was the revision shaft. The main catchment area is the Una river basin. The water area is the water area of the Sava River.Sampling of wastewater was carried out before its discharge into public sewage systems, i.e., into another receiver, in accordance with the Regulation on conditions for discharge of wastewater into natural recipients and public sewage systems (Official Gazette of the Federation of Bosnia and Herzegovina; number 26/20). Accredited test methods for nitrate nitrogen and total ammonia nitrogen are as follows: $NO_3^-$-N – BAS ISO 7890/3:2002, $NH_4$-N – ISO 7150-1:2002, and total nitrogen is determined by calculation. All obtained values were related to mean daily averages based on a 24-hour composite sample proportional to the wastewater flow.

## 2. EMPIRICAL EVIDENCE
## Significance of the ISO 14001 standard

The International Organisation for Standardization 14001 Environmental Management System standard provides a guideline for an organization to perform continuous improvement to their environmental performance. In light of continued concerns over global environmental impacts and climate change, the ISO 14001 standard serves to demonstrate organizational commitment to sustainable production processes (Hengky et al., 2018).The international standard ISO 14001 is the most well-known standard of the ISO 14000 series and specifies the requirements for all organizations, of any type or size, to implement an environmental management system. An environmental

management system is a practical tool for environmental initiatives that can ultimately generate financial benefits through market competition or organizational improvement: cost reduction and revenue growth. These benefits have encouraged companies to implement the ISO 14001 standard, which is today the most popular environmental management standard. The implementation of the ISO 14001 standard brings benefits to companies that adopt it, which are visible through measures to improve environmental protection, profitability, efficiency, image improvement, customer satisfaction and improvements in employee satisfaction. Benefits and advantages can be manifested through various effects: internal effects such as cost reduction, improvement of environmental protection, increased productivity, increased profit margin, improvement of internal procedures, improvement of employee morale, then external marketing effects such as improvement of corporate image, increased market share, increased customer satisfaction, increased time and delivery to customers. In addition, there are advantages in relation to the environment such as improved relations with communities, improved relations with the authorities.The six key factors of the successful implementation of ISO 14001 in order of importance are as follows: management support and commitment; awareness, involvement and competence of employees; government initiatives and commitment; sufficient organizational resources; adoption of a continuous, integrative and collaborative approach and the use of external consultants.During the introduction and implementation of the standard, the following steps are defined: environmental protection policy and analysis of problems in environmental protection, identification of key factors that have an impact on the environment, introduction and implementation of the ISO 14001 standard, measurement and evaluation of implemented activities, and certification and work on continuous improvement (Zilahy, 2017).

## Average values of nitrogen compounds before and after the introduction and implementation of ISO 14001

Almost all industrial and domestic wastewater contains both organic and inorganic nitrogen. The problem of nitrogen compound removal was developed in connection with the deterioration of water quality in rivers and lakes as a result of eutrophication.Wastewater from meat industries contains high concentrations of nitrogen compounds, mainly in the form of ammonium nitrogen (Zhukova & Sabliy, 2011).

The average values of nitrate nitrogen ($NO_3$-N) measured in the period before the introduction of environmental protection standards ranged from a minimum of 3.2 mg/l, which was measured in January, to a maximum of 18.9 mg/l, which was in March, while the concentrations of nitrogen nitrate ($NO_3$-N) measured during the implementation period of the ISO 14001 standard ranged from a minimum of 1.2 mg/l in July to a maximum of 12.3 mg/l, which was the concentration in October. The lowest value of 3.7 mg/l concentration of ammonia nitrogen ($NH_4$-N) was measured in the month of January, and the highest value of 10.00 mg/l in the month of February, before the ISO 14001 standards were implemented in the company, and after the implementation of the standard, the lowest concentration value in the amount of 0.29 mg/l was measured in July, and the highest of 6.49 mg/l in August. The lowest average value of total nitrogen concentration in the period before the introduction of the ISO 14001 standard in the amount of 3.90 mg/l was measured in the month of June, and the highest in the month of March was 43.10 mg/l, while in the period of the implementation of the ISO 14001 standard on environmental protection the lowest total nitrogen measured in July was 1.16 mg/l, and the highest average concentration value was recorded in September and was 32.30 mg/l. In the period from January to June, before the introduction of environmental protection standards, the average value of the concentration of nitrate nitrogen ($NO_3$-N) was Me = 8.6667 mg/l, with a standard deviation SD = 5.6056 mg/l with an error of the average evaluation SE = 2.2885 mg/ l and with a range of average values from a minimum of 3.20 mg/l to a maximum of 18.9 mg/l, while in the period July-December when the company implemented the requirements of the ISO 14001 standard on environmental protection, the average value was Me = 5.583 mg/l with SD = 3.87165 and an error rating SE = 1.58059 and a range of values from Min. = 1.20 to Max. = 12.3 mg/l. The average value of the concentration of ammonia nitrogen ($NH_4$-N) in the period before the introduction of the standard was Me = 7.5117 with SD = 2.449, error of assessment SE = 0.9998 with a range of values from the minimum Min. = 3.70 mg/l to maximum Max. = 10.0 mg/l, while the average value of ammonia nitrogen concentration measured in the period when the ISO 14001 environmental protection standards were implemented was Me = 3.953, with a standard deviation SD = 2.16715 and an error of assessment SE = 0.88474, and a range of values from Min. = 0.29 mg/l to Max.= 6.49 mg/l. The average value of the concentration of total nitrogen in the period before the introduction of the standard was Me = 21.4917, with SD = 15.91941, with SE = 6.49907, with a range of values from a

minimum of 3.90 mg/l to a maximum of 43.1 mg/l, while the average value of the concentration of total nitrogen in period of application of environmental protection standards amounted to Me = 19.1267, with SD = 12.95878, with an error of assessment SE = 5.29040, with a range of values from the minimum Min. = 1.16 mg/l to maximum Max. = 32.3 mg/l (Muminović, 2023).

## Environmental impact from nitrate nitrogen

Despite the European Nitrate Directive (ND) being issued almost 30 years ago, groundwater nitrate contamination is still a serious threat to ecosystems and human health (Musacchio et al., 2020). ND requires EU Member States to monitor the quality of waters and to identify areas that drain into polluted waters or are at risk of pollution. Due to agricultural activities, these concern waters are eutrophic or could contain a concentration of more than 50 mg/l of nitrates. Those areas are defined as Nitrate Vulnerable Zones (ND; 91/676/EEC).

Based on the calculated average value of the concentration of nitrate nitrogen (cNS) and the flow of wastewater (q) at the daily level of monitoring (24h), we evaluated the ecological damage of the total nitrate nitrogen that is excreted in wastewater based on the daily load (g/day) of wastewater.Before analyzing the obtained results according to the period of observation, we calculated the deviation of the average values of the concentration of nitrate nitrogen from the limit value LV = 10 mg/l of the presence of nitrate nitrogen in wastewater.The analysis showed that in the period before the introduction of the standard, the difference between the average concentration of nitrate nitrogen and the permissible limit value LV = 10 mg/l, ranged from 6.80 mg/l, which was in January, to 8.90 mg/l, which was measured in March. During the period of implementation of the requirements of the ISO 14001 standard on environmental protection, deviations from the limit value ranged from 8.82 mg/l in July to 2.30 mg/l in October.In the period before the introduction of the standard, the daily nitrate-nitrogen load of wastewater had a range from the lowest load measured in January, when it was 1420.8 g/day, to the maximum value of 12927 g/day measured in March, while the range of the measured daily value was nitrate-nitrogen load in the period of implementation of the ISO 14001 standard on environmental protection ranged from a minimum value of 547.2 g/day measured in July to a maximum daily load of 6612.48 g/day measured in October. The t-test of paired samples showed no statistically significant difference

in the harmfulness of total nitrate nitrogen compounds measured by the daily load of wastewater before and after the introduction of the ISO 14001 standard on environmental protection t(10) = 1.327, Sig. = 0.214 at the level of statistical significance p = 0.05, and the average value of the difference between the daily load is M(R) = 2531.32, g/day with an error of estimation of the average difference of SE = 1907.062 and 95% CI: from 1717.881 g/day to 6780.521 g/day.The Mann-Whitney U test revealed that the average value of the median daily nitrate nitrogen load in the period before the introduction of the standard (N = 6; Md = 4902.48, with SD = 4102.09464) does not statistically significantly differ from the average value of the median daily wastewater load in the period of implementation of the standard (N = 6; Md = 1860.4800, SD = 2234.76030), U = 10.000, z = -1.281, Sig. = 0.240, at the level of statistical significance p = 0.05. The Mann Whitney U test confirmed that the null hypothesis should be accepted that the distributions of the daily wastewater load with nitrate nitrogen ($NO_3$-N) are the same before and after the introduction of the 14001 standard and that the differences are randomSig. = 0.240 (Muminović, 2023).

## Ecological impact from total ammonia nitrogen

According to Constable et al., 2003, ammonia is released into the environment by many industries and other human activities.Municipal and industrial wastewater are the major quantifiable source of ammonia released to aquatic ecosystems. Given the sources of ammonia releases in the environment and the properties of the substance, terrestrial plants and aquatic organisms are potential risk targets.

Based on the obtained values for the concentration of ammonia nitrogen (cAA), the daily flow of wastewater (q) and the daily monitoring (24h), we analyzed the environmental damage from the total ammonia nitrogen excreted in the wastewater based on the daily load (g/day) of wastewater. Before the analysis of the daily load of wastewater with ammonia nitrogen, an analysis of the deviation of the measured concentration of ammonia nitrogen from the limit value LV = 10 mg/l was performed, before and after the introduction of the ISO 14001 standard. The analysis showed that in the period before the introduction of the standard, from January to June month, the difference between the average concentration of ammonia nitrogen and the permitted limit value LV = 10 mg/l, ranged from 0.00, which was in February, to 6.30 mg/l, which was in January at the beginning of the measurement, while

in the period from from July to December, when the requirements of the ISO 14001 standard on environmental protection were implemented, the deviations from the limit value were significantly higher and ranged from a minimum of 3.51 mg/l in August to a maximum deviation in July of 9.71 mg/l.In the period before the introduction of the standard, the daily load of wastewater with ammonia nitrogen ranged from the lowest load measured in June, which was 2714.4 g/day, to the maximum value measured in the month of February, when it was 7248 g/day, while the measured value of the daily load in during the period of implementation of the ISO 14001 standard on environmental protection, it had a range from the minimum value of 132.24 g/day, which was in July, to the maximum daily load of 3271.2 g/day. The t-test of paired samples showed that there is a statistically significant difference in the harmfulness of total ammonia nitrogen compounds measured by the daily load of waste water in the period before and after the introduction of the ISO 14001 standard on environmental protection t(7.287) = 2.582, Sig. = 0.035 at the level of statistical significance p = 0.05, and the average value of the difference between the daily workload is M(R) = 2677.516 with the error of the average difference estimate of SE = 1036.89694 and 95% CI: from 3245.0610 to 5109.971.The Mann-Whitney U test revealed a statistically significant difference in the average values of the median daily load with ammonia nitrogen in the period before the introduction of the standard (N = 6; Md = 4595,952, with SD = 2278,976) from the average values of the median daily load in the period of implementation of the standard (N = 6; Md = 1841.088, SD = 1121.2487), U = 5000, z = -2.082, Sig. = 0.041, at the level of statistical significance p = 0.05. The median daily load of wastewater in the period before the introduction of the standard (Md = 4595,952) is higher than the median daily load of ammonia nitrogen in the period after the introduction of the standard (Md = 1841,088). The Mann-Whitney U test confirmed that the null hypothesis that the distributions of the daily load of wastewater with ammonia nitrogen ($NH_4$-N) are the same before and after the introduction of the 14001 standard should be rejected, but that the alternative hypothesis that there is a statistically significant difference in the distribution of the daily load of ammonia nitrogen should be accepted before and after the introduction of the standard p = Sig. = 0.041 (Muminović, 2023).

## Ecological impact from total nitrogen

Nitrogen pollution, leading to eutrophication of inland waters, has resulted in an increase in global algal biomass and photosynthesis, such that primary production is approximately 60% higher than expected background levels in lakes, streams and rivers.Total nitrogen concentrations have tended to increase over the years, as a consequence of demographic, industrial and agricultural development (Xu et al., 2014).

Based on the estimated average value of the concentration of total nitrogen (cN) and the daily flow (q), the daily load of wastewater with total nitrogen per day was determined. The equivalent of harmfulness from total nitrogen based on the calculated daily load of wastewater expressed in the equivalent number of inhabitants (ENI) is determined by applying the formula EN=TN/12 (ENI), where 12 is the coefficient that translates the load of waste water with total nitrogen into ENI, and this value represents the amount of total nitrogen originating from one inhabitant (g/day). The results of the evaluation of the equivalent of harm from total nitrogen per month showed that in the period before the introduction of environmental protection standards, it ranged from the equivalent of harm that would be realized by 159.12 inhabitants, as measured in June, to the equivalent of harm that would be realized by 2456.70 inhabitants, which was in March. During the period of implementation of the requirements of environmental protection standards, the value of the equivalent of harm from total nitrogen measured by the number of inhabitants ranged from the minimum equivalent of harm that would be achieved by 44.08 inhabitants measured in the month of July to the maximum equivalent of harm that would be made by 1518.10 inhabitants measured in the month of September. The t-test of paired samples showed that the values of the harmfulness equivalent of total nitrogen in wastewater before and after the introduction of the ISO 14001 standard on environmental protection do not differ statistically significantly; $t(10) = 0.776$, Sig. = 0.456, and the average values of the difference between the equivalent of harm M(R) = 342.18933 (ENI) and the error of the average difference assessment of SE = 440.83277 (ENI), and 95% CI: from 640.0473 to 1324.42596 (Muminović, 2023).

## 3. RESULTS AND DISCUSSION

The average values of nitrate nitrogen ($NO_3$-N) measured during the implementation period of the ISO 14001 standard ranged from a minimum of 1.2 mg/l in July to a maximum of 12.3 mg/l, which was the concentration in October. The average values of ammonia nitrogen ($NH_4$-N) measured during the implementation period of the ISO 14001 standard ranged from a minimum of 0.29 mg/l measured in the month of July, and a maximum of 6.49 mg/l in the month of August. In the period of implementation of the ISO 14001 standard on environmental protection, the lowest total nitrogen was measured in July and was 1.16 mg/l, and the highest average concentration value was recorded in September and was 32.30 mg/l. For all three parameters, the average concentration values (mg/l) are lower in the period of implementation of the ISO 14001 standard compared to the period before the implementation of the standard. In the period from January to June, before the introduction of environmental protection standards, the average value of the concentration of nitrate nitrogen ($NO_3$-N) was Me = 8.6667 mg/l, with a standard deviation SD = 5.6056 mg/l with an error of the average evaluation SE = 2.2885 mg/ l and with a range of average values from a minimum of 3.20 mg/l to a maximum of 18.9 mg/l, while in the period July-December when the company implemented the requirements of the ISO 14001 standard on environmental protection, the average value was Me = 5.583 mg/l with SD = 3.87165 and an error rating SE = 1.58059 and a range of values from Min. = 1.20 to Max. = 12.3 mg/l. The average value of the concentration of ammonia nitrogen ($NH_4$-N) in the period before the introduction of the standard was Me = 7.5117 with SD = 2.449, the error of assessment SE = 0.9998 with a range of values from the minimum Min. = 3.70 mg/l to maximum Max. = 10.0 mg/l, while the average value of ammonia nitrogen concentration measured in the period when the ISO 14001 environmental protection standards were implemented was Me = 3.953, with a standard deviation SD = 2.16715 and an error of assessment SE = 0.88474, and a range of values from Min. = 0.29 mg/l to Max.= 6.49 mg/l. The average value of the concentration of total nitrogen in the period before the introduction of the standard was Me = 21.4917, with SD = 15.91941, with SE = 6.49907, with a range of values from a minimum of 3.90 mg/l to a maximum of 43.1 mg/l, while the average value of the concentration of total nitrogen in period of application of environmental protection standard amounted to Me = 19.1267, with SD = 12.95878, with an error of assessment SE = 5.29040,

with a range of values from the minimum Min. = 1.16 mg/l to maximum Max. = 32.3 mg/l. Statistical values of Me (mg/l) and SD (mg/l) were reduced for all three parameters. The t-test of paired samples showed that there is no statistically significant difference in the harmfulness of total nitrate nitrogen compounds measured by the daily load of waste water in the period before and after the introduction of the ISO 14001 standard on environmental protection t(10) = 1.327, Sig. = 0.214 at the level of statistical significance p = 0.05, and the average value of the difference between the daily load is M(R) = 2531.32, g/day with an error of estimation of the average difference of SE = 1907.062 and 95% CI: from 1717.881 g/day to 6780.521 g/day. The Mann-Whitney U test revealed that the average value of the median daily nitrate nitrogen load in the period before the introduction of the standard (N = 6; Md = 4902.48, with SD = 4102.09464) is not statistically significantly different from the average value of the median daily wastewater load in the implementation period (N = 6; Md = 1860.4800, SD = 2234.76030), U = 10.000, z = -1.281, Sig. = 0.240, at the level of statistical significance p = 0.05. The Mann-Whitney U test confirmed that the null hypothesis should be accepted that the distributions of the daily wastewater load with nitrate nitrogen ($NO_3$-N) are the same before and after the introduction of the 14001 standard and that the differences are random Sig. = 0.240. The t-test of paired samples showed that there is a statistically significant difference in the harmfulness of total ammonia nitrogen compounds measured by the daily load of wastewater in the period before and after the introduction of the ISO 14001 standard on environmental protection t(7.287) = 2.582, Sig. = 0.035 at the level of statistical significance p = 0.05, and the average value of the difference between the daily workloads is M(R) = 2677.516 with an error of estimation of the average difference of SE = 1036.89694 and 95% CI: from 3245.0610 to 5109.971. The Mann-Whitney U test revealed a statistically significant difference in the average values of the median daily load of ammonia nitrogen in the period before the introduction of the standard (N = 6; Md = 4595,952, with SD = 2278,976) from the average values of the median daily load in the period of implementation of the standard (N = 6; Md = 1841.088, SD = 1121.2487), U = 5000, z = -2.082, Sig. = 0.041, at the level of statistical significance p = 0.05. The median daily load of wastewater in the period before the introduction of the standard (Md = 4595,952) is higher than the median daily load of ammonia nitrogen in the period after the introduction of the standard (Md = 1841,088). The Mann-Whitney U test confirmed that the null hypothesis that the distributions of the

daily load of wastewater with ammonia nitrogen ($NH_4$-N) are the same before and after the introduction of the 14001 standard should be rejected, but that the alternative hypothesis that there is a statistically significant difference in the distribution of the daily load of ammonia nitrogen before and after the introduction of the standard should be accepted p = Sig. = 0.041. The t-test of paired samples showed that the values of the harmfulness equivalent of total nitrogen in wastewater before and after the introduction of the ISO 14001 standard on environmental protection do not differ statistically significantly; t (10) = 0.776, Sig. = 0.456, and the average values of the difference between the equivalent of harm M(R) = 342.18933 (ENI) and the error of the estimate of the average difference of SE = 440.83277 (ENI), and 95% CI: from 640.0473 to 1324.42596.

## CONCLUSION

The ISO 14001 standard provides the basis for optimizing the functioning of the environmental protection system. By respecting all the requirements of the mentioned standard, we can minimize the concentrations of compounds that are an integral output of one production. Within this research, the average values of concentrations of nitrogenous compounds (mg/l) are lower in the period of implementation of the ISO 14001 standard compared to the period before the implementation of the standard. For nitrate nitrogen, ammonia nitrogen and total nitrogen, the statistical values of Me (mg/l) and SD (mg/l) were reduced during the standard implementation period. The t-test of paired samples showed no statistically significant difference in the harmfulness of total nitrate nitrogen compounds measured by the daily load of wastewater before and after the introduction of the ISO 14001 standard on environmental protection. The Mann-Whitney U test revealed that the average value of the median daily nitrate-nitrogen load in the period before the introduction of the standard does not statistically significantly differ from the average value of the median daily wastewater load in the period of implementation of the standard. The Mann-Whitney U test confirmed that the null hypothesis should be accepted that the distributions of the daily load of wastewater with nitrate nitrogen are the same before and after the introduction of the 14001 standards and that the differences are random. The t-test of paired samples showed a statistically significant difference in the harmfulness of total ammonia nitrogen compounds measured by the daily load of wastewater before and after the introduction of the ISO 14001 standard on environmental protection. The Mann-Whitney U test

revealed a statistically significant difference in the average values of the median daily load with ammonia nitrogen in the period before the introduction of the standard from the average values of the median daily load in the period of implementation of the standard. The Mann-Whitney U test confirmed that the null hypothesis that the distributions of the daily load of wastewater with ammonia nitrogen are the same before and after the introduction of the 14001 standard should be rejected, but that the alternative hypothesis that there is a statistically significant difference in the distribution of the daily load of ammonia nitrogen before and after the introduction of the standard should be accepted. The t-test of paired samples showed that the values of the harmfulness equivalent of total nitrogen in wastewater before and after the introduction of the ISO 14001 standard on environmental protection do not differ statistically significantly.

# OKOLIŠNE KORISTI UVOĐENJA I IMPLEMENTACIJE NORME ISO 14001 U MESNOJ INDUSTRIJI IZRAŽENE KROZ KONCENTRACIJE DUŠIKOVIH SPOJEVA U OTPADNIM VODAMA

**Faris Muminović**
**Slobodanka Pavlović**
**Halid Makić**

**Sažetak:**

Dušikovi spojevi koji su bili predmet istraživanja su: nitratni dušik (NO3-N), amonijačni dušik (NH4-N) i ukupni dušik (N). Vrijednosti navedenih parametara praćene su prije uvođenja i implementacije norme ISO 14001 (razdoblje siječanj-lipanj) te nakon uvođenja i implementacije (razdoblje srpanj-prosinac). Vrijednosti nitratnog dušika (NO3-N), amonijačnog dušika (NH4-N) i ukupnog dušika (N) izražene su u mg/l (njihove minimalne i maksimalne vrijednosti) s pripadajućim graničnim vrijednostima. Također, zabilježene su prosječne vrijednosti koncentracija dušikovih spojeva (Me, mg/l) sa standardnim odstupanjima (SD, mg/l) i pogreškama prosječne procjene (SE, mg/l). Predmet izračuna je dnevno opterećenje otpadnih voda ukupnim dušikom po danu, kao

i ekvivalent štetnosti od ukupnog dušika izražen u ekvivalentnom broju stanovnika. Prije navedenih proračuna pristupilo se proračunu odstupanja od graničnih vrijednosti. Dobiveni rezultati procjene ekvivalenta štete obrađeni su t-testom (usporedba prije i nakon uvođenja i primjene norme ISO 14001). Dnevno opterećenje otpadnih voda amonijačnim i nitratnim dušikom izračunato je uzimajući u obzir prosječne vrijednosti koncentracija navedenih spojeva i dnevni protok, a prije toga se pristupilo proračunu odstupanja od graničnih vrijednosti. T-testom je uspoređena štetnost navedenih spojeva prije i nakon uvođenja i primjene norme ISO 14001. Mann-Whitney U test korišten je za ispitivanje prosječnih vrijednosti srednjeg dnevnog opterećenja amonijakom i nitratnim dušikom. Također su testirane hipoteze: raspodjela dnevnog opterećenja otpadnih voda amonijačnim dušikom jednaka je prije i nakon uvođenja norme ISO 14001, a raspodjela dnevnog opterećenja otpadnih voda nitratnim dušikom ista je prije i nakon uvođenje standarda ISO 14001.

***Ključne riječi:*** *ISO 14001, dušikovi spojevi, prosječne vrijednosti, ekvivalent štetnosti, dnevno opterećenje otpadne vode, t-test, Mann-Whitney U test*

## LITERATURE

**1.** Constable, M., Charlton, M., Jensen, F., McDonald, K., Craig, G., & Taylor, K. W. (2003). An Ecological Risk Assessment of Ammonia in the Aquatic Environment. Human and Ecological Risk Assessment: An International Journal, 9(2), 527–548. https://doi.org/10.1080/713609921

**2.** Council Directive of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources (91/676/EEC)

**3.** Hengky K. Salim, Rory Padfield, Sune Balle Hansen, Shaza Eva Mohamad, Ali Yuzir, Khadijah Syayuti, Mun Hou Tham, Effie Papargyropoulou. (2018) Global trends in environmental management system and ISO14001 research. Journal of Cleaner Production. Volume 170 Pages 645-653. ISSN 0959-6526

**4.** Kuzlyakina Yu.A., Yurchak Z. A., Baskhamdgieva B. D. (2019). Analysis of environmental aspects at meat processing plants according to ISO 14001. Food systems. 2019; 2(3): 23–28. DOI: 10.21323/2618–9771–2019–2–3–23–2

**5.** Muminović, F. (2023). Ecological benefits of the implementation of BAS ISO 14001 in the company MS-ALEM d.o.o. Bosanska Krupa, Master thesis, University of Bihać, Bosnia and Herzegovina

**6.** Musacchio A, Re V, Mas-Pla J, Sacchi E. EU Nitrates Directive, from theory to practice: Environmental effectiveness and influence of regional governance on its performance. Ambio. 2020 Feb;49(2):504-516. doi: 10.1007/s13280-019-01197-8. Epub 2019 May 21. PMID: 31115872; PMCID: PMC6965048.

**7.** Shen, T.T. (1995). Industrial pollution prevention 2nd ed. Springer

**8.** Wadhwa RR, Marappa-Ganeshan R. (2024). T Test. Treasure Island (FL): StatPearls Publishing; 2024 Jan-. Available from: https://www.ncbi.nlm.nih.gov/books/NBK553048/

**9.** Xu Z, Zhang X, Xie J, Yuan G, Tang X, Sun X, Yu G. Total nitrogen concentrations in surface water of typical agro- and forest ecosystems in China, 2004-2009. PLoS One. 2014 Mar 25;9(3):e92850. doi: 10.1371/journal.pone.0092850. PMID: 24667701; PMCID: PMC3965473.

**10.** Zhukova, Veronika & Sabliy, Larisa & Lagod, Grzegorz. (2011). Biotechnology of the food industry wastewater treatment from nitrogen compounds. Proceedings of ECOpole. 5. 133-138.

**11.** Zilahy, G. (2017). Environmental management systems-history and new tendencies, Budapest University of Technology and Economics. Hungary