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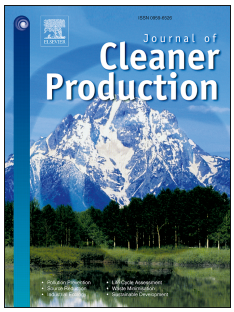

Assessment of environmental practices in Serbian meat companies

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Title: **Assessment of environmental practices in Serbian meat companies**

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Abstract

The meat industry is recognized as one of the biggest polluters in the food industry. Previous studies were much more focused on environmental impacts of the meat industry than on the environmental practices within the meat chain. The aim of this study was to assess environmental practices in Serbian meat companies. The study examined 16 slaughterhouses slaughtering 62.5% of the national production, and 14 meat processing plants contributing 58.2% of meat processing nationally. The level of implementation of environmental practices was evaluated in respect to managing energy usage, water usage, waste handling and wastewater discharge, deployed through five topics: Policy and Objectives; Operational Knowledge; Communication; Performance Measurement and Analysis. Results were examined in respect to the size and type of the meat company and their certification status. Higher levels of implementation of environmental practices were found in large companies as opposed to micro and small sized companies, in slaughterhouses compared to meat processing plants and in certified companies than in non-certified companies. Performance measurement for usage of energy, usage of water and waste water discharge scored the highest. Principal component analysis was used to reduce the dimensionality of the environmental practices into two principal components, termed 'environmental dimension' and 'economic dimension'. The 'environmental dimension' obtained higher loadings than the 'economic dimension' for most of the topics within water, waste and waste water impacts. Energy as an impact was heavily loaded on the 'economic dimension', emphasizing that companies found the greatest financial benefit in energy saving. This bottom-up approach in analyzing environmental practices on-site provides new evidence relating to the meat sector. It can help environmental specialists and managers in the meat sector, directing them as to how to improve environmental practices. Finally, our assessment tool could also motivate other food sectors in analyzing their environmental impacts.

Keywords: energy, environmental impact, meat industry, waste, waste water, water

Article Classification – Research paper

1 Introduction

Environmental impacts arise from emissions into the environment as well as from the consumption of resources associated with the production of goods (Lopez-Ridaura et al., 2009). Meat is considered as the food product with the greatest environmental impact, mostly from livestock farms (Röös et al., 2013). Compared with the agricultural phase, environmental impacts of other stages such as slaughtering, processing, storage and retail, although lower (Peters et al., 2010), are still of importance for research. The main environmental aspects associated with meat slaughtering and processing are, on one hand, water and energy consumption, and on the other, discharge of waste water and solid waste (IFC, 2007; IPPC, 2006).

Water is consumed in all stages of meat processing, starting from the first step when the live animal enters the facility, until the last step, when meat products are dispatched from the meat processing plant (Kupusovic et al., 2007). A considerable amount of energy is used in meat processes involving heat treatments (boiling, cooking, pasteurizing, sterilizing drying and smoking) and cooling (chilling, freezing) (IPPC, 2006).

Several activities are associated with the generation of waste water in the meat industry, including washing of livestock, carcasses and offal, cleaning and/or sterilization of knives, equipment, work surfaces and floors, plus workers' personal hygiene and truck washing (Kupusovic et al., 2007). Wastewater contains pollutants such as blood, fat, manure, undigested stomach contents, meat and meat extracts, dirt and cleaning agents. Solid waste consists mainly of inedible products (bone, fat, heads, legs, skins, hair and offal) and various packaging materials (paper, plastic, metal) (Kupusovic et al., 2007). In the EU, the use of animal by-products is controlled by Regulation 1069/2009 (EC, 2009).

Besides the food sector and current technologies that affect the environment, the main factor influencing the environmental performance is the environmental practice in food companies. These practices can range from passive or reactive strategies that merely aim to comply with requirements and introduce some basic end-of-pipe solutions, to more advanced or proactive strategies (Guerrero-Baena et al., 2014; Murillo-Luna et al., 2011). Environmental practice is mostly implemented in order to improve a company's (environmental) performance (Johnstone and Labonne, 2009).

The objective of this research was to assess environmental practices in slaughterhouses and meat processing plants in terms of four environmental impacts: usage of energy, usage of water, waste handling and wastewater discharge. All impacts were examined through the same five topics: Policy and Objectives; Operational Knowledge; Communication; Performance Measurement and Analysis. The level of environmental practice implementation was compared in relation to the companies' roles in the meat chain, size of the companies and their certification status.

1.1 Literature review

A literature review was performed by analyzing published articles. The major sources of information were the scholarly databases Web of Science, EBSCO and ScienceDirect, which identified relevant academic articles published in the domains of environmental impacts (more specifically: environmental protection and/or environmental management of various impacts – waste, water, energy, wastewater) as well as the meat chain (more specifically: meat processing, slaughterhouses, food). There were no geographical restrictions applied, and the search was limited to papers published from the year 2000. The selection criteria chosen to identify the relevant articles were related to the objectives of this paper: (1) focus on the specific environmental impacts in slaughterhouses and/or meat processing plants; (2) focus on environmental practices/management in slaughterhouses and/or meat processing plants.

The majority of published research/studies related to the environmental impacts of the meat industry were focused on the following: (i) product-based research mainly through life cycle assessment (LCA); (ii) company-based research, based on various environmental management tools; (iii) a combination of the two.

Reckmann et al. performed a study on LCA in pork production, analyzing six LCA studies (Reckmann et al., 2012). The main environmental impacts identified in pork production were global warming potential, acidification, eutrophication and use of resources. Another author calculated up to 15 different environmental impact categories in the meat chain (Nguyen et al., 2012). Depending on the system boundaries (pig farming house, slaughter house and meat processing plant), the three most commonly used functional units for the expression of the results were: one kg of pig produced (Basset-Mens and van der Werf, 2005; Dalgaard et al., 2007); one kg of pig carcass (Nguyen et al., 2011; Williams et al., 2006) and one kg of bone- and fat-free meat (final product), (Cederberg and Flysjö, 2004). The same functional units and environmental impacts were confirmed in the works of Cherubini et al. and Röös et al., analyzing over 20 LCA studies (Cherubini et al., 2014; Röös et al., 2013). Environmental costs through the LCA approach were explored in the work of Nguyen et.al., focusing on pig farms as the major polluters in the meat chain (Nguyen et al., 2012). Spanish slaughterhouses recognize water consumption, generation of waste water with a high organic load and the energy input needed to refrigerate and to heat water as main environmental aspects (Bugallo et al., 2014).

Effects and benefits of an implemented environmental management system (EMS) have been analyzed by various authors who focused their research on three topics: drivers and motivation in implementing EMS; costs and financial issues in implementing EMS and benefits and effects of implemented / certified EMS (Djekic et al., 2014b). With regard to the timing of the research, three different types of evaluations were recognized: *ex ante* (prior to implementation of the management system), ongoing/mid-term (during the implementation procedure) and *ex post* (after the implementation).

Reasons for implementation of an EMS are increased market share, and access to new markets in line with expected financial, social and environmental benefits (Gavronski et al., 2008; Massoud et al., 2010), and improved regulatory compliance (Gavronski et al., 2008).

Regarding financial performance, companies can harbor the belief that environmental management increases costs and reduces profit (Chen et al., 2015). This is specifically present in small and medium sized companies that perceive adoption of environmental practices as costly (To et al., 2015). However, several authors have confirmed that environmental practices may lead to innovations and contribute to reducing costs (Hofer et al., 2012; Wolf, 2011).

Focuses of research on environmental practices have included differing countries / economies, as in the work of Chen at al., where performance was analyzed in Sweden, China and India (Chen et al., 2015). Research has been devoted to differing industries such as hotels (Mensah, 2006), the construction industry (Shen and Tam, 2002) or public administration (Nogueiro and Ramos, 2014). Finally, some authors have explored environmental practices in terms of the size of companies (Larrán Jorge et al., 2015; Teles et al., 2015). However, the literature search revealed that the meat industry has not been a focus of such research, and so this was identified as a research gap by the authors of this paper.

1.2 Meat industry and legal environment in Serbia

Serbia is economically classified as a country in transition. According to the level of development measured by per capita gross national income, Serbia is classified as a country with upper middle income (UN, 2012). From the time the Stabilization and Association Agreement (SAA) with the EU was signed in November 2007, to Serbia being granted official candidate status for EU membership by the European Council in March 2012, the Serbian government adapted much of its legislation to comply with the EU's, and enforced the implementation of food industry-related directives, including those related to environmental protection. Finally, the SAA between the EU and Serbia entered into force in September 2013 (MFA, 2014). The primary goal of this legal harmonization was to allow stakeholders in the food chain, from primary production through processing and trade to the final consumer to conduct their activities according to EU regulatory requirements in the fields of the food industry and environmental protection (EU, 2014).

The meat industry is one of the leading food sectors in Serbia, with total annual meat production around 450 thousand tones (Gulan, 2014; Yearbook, 2014). The number of slaughterhouses varies depending on the criteria, i.e. whether the slaughterhouse is only registered as operating a limited number of working days per year (≈ 1,500 slaughterhouses) or is considered as a fully operating slaughterhouse slaughtering at least three days a week (≈ 500 slaughterhouses). Less than 100 slaughterhouses have export permits either for the countries of the Western Balkans, for Russia or for the EU (Gulan, 2014; Serbia, 2015). A processing plant can operate independently or jointly with a

slaughterhouse and/or meat retail outlet. There is no official data regarding the number of processing plants, but the number of processing plants with export permits is below 150 (Serbia, 2015).

Within the agriculture, forestry and fishing sector, the majority of companies (84.6%) employ less than 10 employees (micro companies), 11.9% have between 10 and 49 employees (small companies), and only 3.5% have more than 50 employees (classified as big companies). In the food processing industry, the majority of companies (75.2%) employ less than 10 employees (micro companies), 16.9% have between 10 and 49 employees (small companies), and 7.9% have more than 50 employees (Yearbook, 2014).

The Serbian meat processing industry has started to invest in increasing capacity, technology and standards, but only a few companies have achieved EU standards and comply with legal requirements (Tomašević et al., 2013). According to the list of Serbian establishments approved for food export to the EU (last modified on November 2014), maintained by the official EU Directorate-General for Health and Consumers (DG SANCO), only one poultry slaughterhouse and cutting plant, one meat preparation plant, and eight meat processing plants have received export approval (DG SANCO, 2014). Regarding the legislation related to environmental protection, Serbia has started harmonization with EU laws, regardless of the industry involved.

As outlined in the EU regulation 852/2004, Hazard Analysis and Critical Control Points (HACCP) is a systematic tool used in the food industry in order to identify, assess and control hazards, focusing on the prevention of occurrence of identified hazards (Regulation, 2004). Following its path to the EU, Serbia has introduced implementation of a HACCP-based food safety system within its regulations (Law, 2009; Serbia, 2010b).

2 Materials and methods

Data used in this study were collected by direct, on-site observations of environmental practices at slaughter/meat processing plants (site tours) and through access to the environmental data that companies generate during their activities (assessment of available documentation and records). Duration of each visit was six hours. Authors contacted the companies in advance, emphasizing that the visits were not an official inspection/audit. In order to obtain objective results which accurately reflected their environmental practices, the companies were asked not to perform any preparation activities. The survey was conducted from March 2014 until October 2014. A total of 30 companies were visited. Their representatives (technical managers and HACCP team leaders) were interviewed for the purpose of this survey. Interviews and data assessment lasted approximately four hours. At the opening meeting the authors explained the purpose of the research giving the interviewees an opportunity to present environmental practices in their companies. Upon completion of the opening meeting, the assessment tool was used to ask specific questions in respect to managing energy usage, water usage, waste handling and wastewater discharge.

An assessment tool was developed considering two environmental tools developed in the UK (Brecsu, 2001; CTG, 2013). These tools provide assessments aligned to an organization's achievements in respect to several factors such as policy, organization, competence, communication, performance management and investments. Massoud et al., identifies several categories as challenges in implementing environmental management in the food industry, such as policy, objectives, monitoring and measurement, and staff training (Massoud et al., 2010). Since investment in environmental protection in Serbia is just beginning, the authors selected five topics to be explored for each environmental impact, as follows: Policy and Objectives (PO); Operational Knowledge (OK); Communication (CO); Performance Measurement (PM) and Analysis (AN). Each of the topics consisted of five investigated characteristics.

The first section of the tool included general information about the companies. The second section explored different statements divided into four environmental impacts: water management (Wa), energy management (En), waste water management (Ww) and waste management (Ws). These impacts were chosen as the most dominant in the meat sector (IFC, 2007; IPPC, 2006; Kupusovic et al., 2007). Boiral and Henri confirmed a positive correlation with reduction of environmental impacts, associated with the volume of waste generated, and water and energy consumption in several case studies of implemented environmental management (Boiral and Henri, 2012).

'Policy and Objectives' topic was evaluated in relation to whether the company had documented and implemented a written strategy, written policy, precise environmental objectives, developed action plans for the objectives and whether they had been reviewed each year.

'Operational Knowledge' was assessed in relation to whether the employees were trained for the specific environmental impact, what was the level of awareness, were there precise documents related to the impact, were there training programs for the impact in place and whether there was an appointed person responsible for minimizing the environmental impact.

'Communication' was evaluated based on the existence of a communication channel within the company, regularity of meetings related to the environmental impact, availability of documented environmental performance data, communication with wider stakeholders and the posting of safety signs in order to minimize or to prevent environmental impact.

'Performance Measurement' was assessed in relation to the installation of various measurement devices, frequency of regular environmental monitoring activities, measurement of environmental costs, control of environmental operations and analysis of the main polluters.

'Analysis' was evaluated based on the availability of precise data related to the existence of environmental indicators, calculation of an environmental indicator per functional unit, awareness of the industry environmental benchmarks and connection between established targets and performed analysis.

Each of the statements was evaluated for its level of implementation. The method for assessing all environmental impacts was adjusted according to the UK tools. Briefly, the responses were marked on a scale from 0 to 4, with 4 being the highest mark (Table 1). **Level 0** applies to sites where management of the environmental impacts is virtually non-existent. **Level 1** generally indicates that, although there is no specific policy, some management activities are in place, albeit in a rudimentary or informal fashion. **Level 2** suggests that the importance of management is recognized at a senior management level, but there is little active support for any environmental management activities. **Level 3** indicates that environmental management is treated seriously at a senior level, and is incorporated within formal management structures. **Level 4** is an indication of clear delegation of responsibility for environmental management throughout the organization.

The raw data were grouped into a matrix with the companies as rows and the levels as columns, and were averaged across the four environmental impact areas examined (Wa, En, Ww and Ws). Mean values were compared using ANOVA and Tukey's HSD test. The level of statistical significance was set at 0.05. The matrix of data was analyzed using the principal component analysis method (PCA). All statistical processing was performed using Microsoft Excel 2010 and SPSS Statistics 17.0.

3 Results and discussion

The general characteristics of the 30 meat companies investigated in this research are presented in Table 2. Depending on the main production activity, the companies were categorized as slaughterhouses or processing plants.

Companies included in this survey conduct about 62.5% of meat slaughter and 58.2% of meat processing, within Serbia's national production (Yearbook, 2014). Micro companies included in the survey (≤10 employees) did not export to any market.

Due to the fact that a 'HACCP-based food safety system' is not a management system (Djekic et al., 2011), the authors also asked companies if they held some types of management system certificates, i.e. ISO 9001 related to quality management system (QMS) and/or ISO 14001 related to environmental management system (EMS) (ISO, 2004, 2008). Less than a half of the sampled companies (40%) presented some type of QMS and/or EMS certificate, and the QMS certificates prevailed. Only four companies held both certificates.

3.1 Factors influencing environmental impacts

There were 20 statements (items) deployed into four environmental impact factors. Reliability of item scales was determined by calculating Cronbach's α coefficient (Table 3). This coefficient is a measure of internal consistency and is used to determine if the scale is reliable when there are multiple questions in a tool that form a scale (StatSoft, 2013). Cronbach's α was 0.985, with the same result if any of the items were deleted. Items are considered reliable and unidimensional when Cronbach's α is

higher or equal to 0.70 (alpha values ≥0.80 represented “good” reliability) (Comrey and Lee, 1992; Hair et al., 1998).

Factor analysis with Varimax rotation was performed to identify whether the 20 measurement items reliably reflected the constructs of the examined factors. Eigenvalues were used to decide the number of factors to be retained after extraction (Hair et al., 1998). The analysis showed two components and the cumulative variance explained over 85% of the observed variance.

An overview of the results shows that the highest scores were assigned to 'Performance Measurement' in respect to factors managing 'energy', 'water' or 'waste' (Table 3). Environmental performance is a relationship between the organization and the environment, including environmental effects of resources consumed and the environmental impacts of the organizational processes (Dubey et al., 2015). Our results are in concurrence with research in Brazil where the companies with the best environmental practices were associated with reducing the consumption of natural resources and improving waste treatment (Teles et al., 2015). In the 'waste water management' factor, 'Policy and Objectives' received the highest scores. Overall, the highest score was 2.41 (PM in water management), with none of the scores reaching 3.00. Environmental practices were not recognized as important by top management and there was a lack of their support to improve environmental performance either through monitoring of practices or through setting measurable objectives. Lack of management commitment, inadequate understanding of the management requirements and simply seeking certification instead of striving to implement a good system are the most common causes for inadequate environmental management (Djekic and Smigic, 2013). The lowest scores were assigned to the 'Analysis' topic for all of the four environmental impact factors. This leads us to the conclusion that limited environmental protection practice is in place regarding any type of analysis.

3.2 Level of environmental practice in respect to the size of companies

Results showing the level of environmental practices in the Serbian meat industry are presented in Table 4. The results revealed that small and micro sized companies achieved lower scores than bigger companies. Small companies usually take environmental actions in response to threats and sanctions from regulatory authorities or the government. They respond with end-of-pipe environmental control solutions, which are less effective tools compared to implementing more sound environmental practices and policies, such as cleaner production (Ferenhof et al., 2014). Absence of specific environmental policies and lack of knowledge and experience affect the adoption of environmental practices in small companies (Santos et al., 2011).

With respect to the water management part of the study, there were significant differences between bigger companies and the other two groups of companies (micro and small) for PO, OK, CO and AN. For the 'Policy and Objectives' topic, big companies scored above 3.00 compared to small companies, which scored below 1.00. This difference emphasizes that small companies did not have any

objectives related to water, but had limited management practice related to water management. Big companies scored above 2.20 for the other four topics, while small ones scored around 2.00 only for 'PM'. Small companies mostly scored below 1.50, confirming limited environmental practice in water management.

Results confirm significant differences between companies below and above 50 employees in energy management for PO, OK and CO. The importance of having an environmental policy and objectives in energy management has been confirmed, regardless of the size of companies (Ates and Durakbasa, 2012). In the current study, bigger companies scored 2.91, showing that they had some formal energy objectives, with their management being engaged in setting these objectives. Schulze et al., in their review paper, identified both energy policy and target setting as essential in analyzing energy practices from a strategic point of view (Schulze et al., 2015).

In the current study, staff in big companies tended to have at least some environmental practices in energy management compared to staff in smaller companies (score 2.60 compared to score below 1.25, respectively). 'Communication' was the topic which achieved the lowest scores, since none of the companies scored above 1.50. There was a significant difference in energy management between small and micro companies for PM. However, all scores were between 1.63 and 2.62, meaning that all companies monitor energy at least on a monthly basis. This is similar to another study which emphasized that monitoring of energy consumption supports the judgment of whether energy savings can be achieved or not (Kannan and Boie, 2003). In the current study, there was no significant difference for 'Analysis' of energy management when the size of the companies was taken into account. Small companies showed limited environmental practice (scoring around 1.00) while bigger companies scored only slightly higher, showing that only basic analysis was in place, regardless of company size.

Waste water management was significantly different between big companies and the other two groups (micro and small) for all five topics. Big companies had objectives related to waste water (score 3.49), had high levels of 'Performance Management' in monitoring waste water discharge (score 3.25), employed staff that were aware of how waste water from the meat sector affects the environment (score 2.94), communicated this environmental aspect (score 2.64) and analyzed the effects of this aspect on the environment (score 2.31). On the other hand, all scores for smaller companies were below 1.20, meaning that this environmental impact was not managed by these companies.

The waste management part of our research also confirmed significant differences between big companies and the other two groups (micro and small) for all five topics. Scores for companies with over 50 employees were between 2.36 for 'Analysis' and 3.40 for 'Policy and Objectives', meaning that these companies had formal objectives related to waste management. They also had staff which was trained in waste management. Monitoring and analysis were at a high level, with environmental impacts being expressed per functional unit of the product (kg of meat). Smaller companies scored

below 2.00, leading us to conclude that these companies also expressed some degree of environmental practice awareness/implementation in respect to waste management, although at a lower level.

3.3 Level of environmental practice in respect to certification status

Certified companies achieved higher scores (between 1.83 and 3.18) compared to non-certified companies. This is expected since both ISO 9001 and ISO 14001 are management standards having all five topics as generic requirements (ISO, 2004, 2008). To develop an EMS, an organization has to assess its environmental impacts, set targets to reduce these impacts, and plan how to achieve the targets (Djekic et al., 2014b). An effective EMS is aimed at reconciling economic growth with environmental issues (Seiffert, 2008). The use of EMS is recognized as important in controlling waste water and air emissions and reducing environmental impacts from accidents (Phan and Baird, 2015).

In the current study, within all four environmental impacts, topics related to PO, OK and CO were significantly different between certified and non-certified companies. EMS promotes the prescription and enforcement of environmental goals, policies and responsibilities (Seiffert, 2008). 'Performance Management' was significantly different for waste and waste water management impacts. Non-certified companies achieved results below 2.00, while certified companies expressed commitment of their management to improve these two impacts (scores above 3.00). 'Analysis' as a topic was significantly different in terms of water, waste and waste water management between certified and non-certified companies. Considering that analysis may drive improvements, this confirms the intention of implementing an EMS, since it strives to improve the environmental performance on all environmental aspects, including legal compliance (Djekic et al., 2014b).

3.4 Level of environmental practices in respect to the meat sector

Overall, slaughterhouses were better rated compared to processing plants. In managing water usage, energy usage and wastewater discharge, there were no statistically significant differences between the two main sectors. Between sectors, the only significant difference in managing waste was between results for 'Performance Measurement'.

Scores for slaughterhouses were between 1.38 (analysis in managing waste water) and 2.69 (PM in managing waste). On the other hand, scores from meat processing plants ranged between 1.00 (analysis in managing waste water) and 2.21 (PM in water usage).

3.5 Principal component analysis

Bartlett's test of sphericity was significant ($p < 0.000$) and Kaiser-Meyer-Olkin measure of sampling adequacy was satisfactory (0.683). Bartlett's test of sphericity is used to test if the data are suitable for data reduction i.e. the level of correlation between the variables. The Kaiser-Meyer-Olkin measure is used as an index of whether there are linear relationships between the variables and whether it is

appropriate to run a principal component analysis on the current data set. When values are above 0.6, it is suggested that the principal component analysis may be useful (Kaiser, 1974).

The first two extracted principal components (PC), representing 85.8% of total variance explained, were taken into consideration in further analysis related to the eigenvalues. PCA output for the data matrix is shown in Figure 1. Dimension reduction by PCA separated the observed factors into two distinct directions.

Therefore, the authors recognized two dimensions: an 'environmental dimension' (PC1) directed towards managing environmental impacts on site and an 'economic dimension' (PC2) as a dimension directed towards analyzing environmental performance in respect to financial benefits. Several authors confirm a relationship between environmental and economic performance (Al-Tuwaijri et al., 2004; Muhammad et al., 2015).

By building on the extant literature that supports sustainability in the food industry, affirmation of these two dimensions, the environmental and the economic, contributes to the analysis of the meat chain's sustainability.

A loading plot (Figure 1a) gives a summary of the results. From Figure 1a, it is obvious that all results show positive loadings, meaning that they have a strong positive influence on the two extracted components. Results contributing to similar information are grouped together, showing that they are correlated.

The distances to the origin convey information, in that the farther away from the plot origin a result lies, the stronger impact that result has. The 'environmental dimension' (PC1) was loaded heavily (> 0.70) with water, waste and waste water impacts and categories PO, OK, CO. The PM topic was heavily loaded for waste and waste water impacts. These topics are all related to a company's practice of impact management through the deployment of policy and objectives, raising awareness of employees, communication and measurement of the environmental performance. The loadings of these impacts and topics are higher in the 'environmental' than in the 'economic' dimension (< 0.55), showing that companies barely recognize any financial benefits when they manage these environmental impacts.

On the other hand, the 'economic dimension' highlighted management of energy usage in the categories PM and AN, emphasizing that companies found the highest financial benefit in energy saving through 'Performance Measurement' and 'Analysis' (loading >0.80). All loadings of energy topics were higher in the 'economic' than in the 'environmental' dimension, emphasizing that energy is considered more as a financial than as an environmental issue.

'Analysis' as a topic showed loadings above 0.50 for both components for the three environmental impacts – water, waste and waste water. This leads to the conclusion that companies are willing to improve their environmental performance by analyzing data only if this can produce financial benefits.

The loadings of PM in water management were low for both dimensions (< 0.40 for the environmental and <0.20 for economic dimension), meaning that companies did not recognize water consumption as an environmental impact or as an economic issue. The reason lies in the fact that the price of water in Serbia is lower than in developed countries and water consumption was not recognized as being important by the plant managers (Djekic et al., 2014a).

The scores plot (Figure 1b) gives a summary of the relationships among the companies. Results close to each other are similar, whereas those far from each other are dissimilar. Big and certified companies were grouped together, representing companies with similar environmental practices. Companies based on their activity (slaughterhouse vs. processing) were located close to the center indicating that they shared similar average environmental practice scores.

After the comparison of the scores plot with the loading plot, the authors identified the relationship between the results and the companies. Figures 1a and 1b reveal that the focus of micro companies and companies that were not certified was not environmental management, while bigger and certified companies have expanded their focus to the environment when they felt this would bring specific economic benefits.

3.6 Opportunities for improvement

Most of the companies show great potential for environmental management improvement. Namely, only 20.0% of the companies reuse condensate and only a half of them had timers installed to automatically shut off water flow when water is not required. Less than a half used detergents that can easily be removed with a little water. Fewer than 20.0% of the companies had systems in place to capture and reuse rain water and storm water for landscaping, or for other uses (e.g., cooling tower make-up, process water, or dust suppression). Water permits were in place in 80.0% of the companies as required by the Water Law (Serbia, 2010d).

More detailed analysis of infrastructural elements related to energy efficiency confirmed that the majority of the companies had buildings with solid walls (93.3%), insulated roofs (73.3%), insulated walls (80.0%), and insulated steam and hot water pipelines (63.3%). Also, most of the companies (96.7%) were able to set thermostats at adequate temperatures. On the other hand, automated switching on/off of 'Heating, Ventilation and Air Conditioning', using timers, was present in only 40.0% of the companies and programmable lighting control for indoor and outdoor lighting in just 36.6% of them. Improvement potentials in heat and power supply with regard to the size of the plants and energy demands have been identified (Fritzson and Berntsson, 2006). Schulze et al. highlighted the large energy efficiency potential in industry, in terms of reducing energy consumption and energy costs (Schulze et al., 2015).

Two thirds of the companies had some sewage system in place. Most of the companies had physical treatment (53.3%), while less than a third of the companies reported having either biological or

chemical treatment. Waste water permits were held by 80.0% of the companies as required by the Water Law (Serbia, 2010d). However, almost half of the companies did not check the quality of their waste water as required by the Regulation which came into force during 2010 (Serbia, 2010a). When Poland was accessing the EU, it was estimated that more companies had temporary than valid permits, since valid permits were issued in respect to the pollutants in the waste water, but temporary permits could be issued without reference to any specific pollutants (Kathuria, 2006).

Inefficient management of liquid wastes in slaughterhouses results in severe environmental damage, since uncontrolled spillage leads to changes in the biocenosis affecting the species distribution, and resulting in aquatic ecosystems being the most threatened (Cuadros et al., 2011). In the current study, half of the companies had an emergency response plan in the case of a waste water accident.

In waste management, improvement should focus on prevention of food waste within the life stage, as outlined in EU documents leading to the "zero waste" principle (Mirabella et al., 2014). Waste management is regulated by a Regulation that came into force in 2010 (Serbia, 2010c). It defines transport, treatment, storage, and disposal of all types of waste, including food waste. Within the Serbian Regulation on veterinary and sanitary conditions of meat industry facilities, there is no clear requirement on waste handling (Regulation, 2011). In the EU, the recovery of meat industry by-products is controlled by specific hygiene and health regulations, where the most dangerous disease is Bovine Spongiform Encephalopathy, for which developed markets, including the EU, have legislative measures (Mirabella et al., 2014).

Legal compliance regarding waste management was confirmed in most of the companies, i.e. 76.6% of the companies had a waste management plan, 80.0% of the companies had a register of all types of waste and 86.6% had signed contracts with waste operators (Serbia, 2010c). Companies used closed containers for segregation of waste as this is also a requirement regarding good hygiene practice in meat industry. Development of a system to check container integrity (e.g. holes, leaks or damages) and segregation of different animal by-product categories to avoid cross-contamination are areas for improvement observed in the current study.

4 Conclusions

This study contributes to the literature by providing a more detailed insight into the nature of the environmental practices from a meat-company perspective. It is known that the meat industry has been recognized as the major polluter in the food sector. This study brings to attention the necessity of analyzing various environmental perspectives of meat production within the meat chain. In most studies, the level of implementation of environmental practices in the meat chain has not been analyzed.

The main purpose of this study was to assess the level of implementation of environmental practices in slaughterhouses and meat processing plants in terms of four environmental impacts: energy usage, water usage, waste handling and wastewater discharge.

Implementation level was evaluated with respect to the four impacts examined through five topics: Policy and Objectives; Operational Knowledge; Communication; Performance Measurement and Analysis. 'Performance Measurement' for usage of energy, usage of water and waste water discharge scored the highest, with results between 1.85 and 2.41. 'Policy and Objectives' scored the highest for waste, with a score of 2.30. These scores emphasize that environmental practice is recognized by companies' management, resulting in some limited management commitment being in place. Such companies are working on improving their environmental performance through monitoring or setting measurable objectives for the four objectives. The lowest scores were assigned to the 'Analysis' topic for all four of the environmental impacts. The companies which achieved these scores did not recognize any benefits from analyzing environmental data.

Principal component analysis of the data resulted in dimension reduction of the environmental impacts into two principal components, termed 'environmental dimension' and 'economic dimension'. The 'environmental dimension' obtained higher loadings (>0.70) than the 'economic dimension' for most of the topics, while managing the water, waste and waste water impacts. The 'economic dimension' revealed energy as an environmental impact which, according to the companies' opinion, has the highest potential for financial benefits. Energy topics had higher loadings in the 'economic' than in the 'environmental' dimension.

This research indicates the differences in the levels of implementation of environmental practice with respect to the size of the companies, certification status and meat sector. The level of implementation of environmental practices was higher in large companies as opposed to micro and small sized companies. Slaughterhouses showed better environmental practice than the meat processing plants.

Our results provide practical implications for both the meat sector and the food industry. This bottom-up approach in analyzing environmental practices on-site provides added value regarding analysis of the current environmental practices in the meat chain. Such analysis can help environmental specialists to increase their knowledge regarding the level of environmental practice they can expect in the meat industry. It can also direct managers in the meat chain to develop and improve their environmental practices. The scientific value of this approach is the identification of areas of improvement in the meat chain in respect to managing energy usage, water usage, waste handling and wastewater discharge. Also, affirmation of two dimensions, the environmental and the economic, in this case, contributes to the analysis of the meat chain's sustainability.

A limitation of this research is the fact that the companies were visited only once. The visits didn't include any on-site measurements of environmental impacts in surveyed companies. This research didn't analyze the technological level of surveyed meat companies. Finally, another limitation may be

the relatively small number of companies studied although the companies did have a production share of over 50.0% of the national output for both meat slaughtering and meat processing.

These results can be used as a basis for discussion in order to improve environmental practice and choose alternatives to achieve better environmental performance in the meat chain. Application of the same method to the meat chain in other regions could offer a better insight into practices within the meat chain globally.

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Table 1. Methods for assessing level of implementation

Level	Policy and company objectives	Operational knowledge	Communication	Performance measurement	Analysis
4	Environmental policy, objectives, action plans and regular annual management reviews are in place	Staff understands how their roles impact on the environment and take actions to minimise the environmental impact	Extensive communication of environmental issues to all stakeholders is in place	There are comprehensive performance measurements against targets with effective management reporting	Company calculates several footprints related to energy, water, waste and waste water. Data are presented per functional unit (kg of produced product)
3	Formal environmental policy and objectives exist but there is no active commitment from top management	Staff are aware of how they affect the environment	Regular staff briefings, performance reporting and environmental protection promotion are held in the company	Company monitors environmental aspect / impact by type on a weekly basis	Company converts basic data to calculate environmental impacts per functional unit of the product (kg of meat)
2	Environmental policy and objectives are un-adopted	Environmental practice is in place; Occasional training is held to improve environmental performance	Some communication mechanisms to promote environmental protection are present	Company monitors environmental aspect / impact by type on a monthly basis	Company analyses basic environmental performance
1	There is an unwritten set of environmental guidelines and objectives	Environmental practice is adopted within working practices	Company uses only ad-hoc informal contacts to promote environmental protection	Company only monitors invoices and checks basic reports	Company analyses data related to basic environmental costs (analysis of monthly bills)
0	There are no environmental policy and/or objectives	No consideration is given to environmental aspects	There is no communication of environmental protection	There is no measurement of environmental performance	There is no analysis of environmental performance

Table 2. Profile of the sampled companies

Characteristic	Category	Sample N (%)
Size	Micro companies (≤ 10 employees)	7 (23.33%)
	Small companies (11 – 50 employees)	12 (40.00%)
	Big companies (over 50 employees)	11 (36.67%)
Meat sector	Slaughterhouse	16 (53.33%)
	Meat processing plant	14 (46.67%)
Certificates	Certified companies (quality / environmental management)	12 (40.00%)
	Companies not certified	18 (60.00%)

N represents the number of companies; (%) represents their share in the sample

Table 3. Reliability tests and factor loadings

Factors	Items	Loadings[1]	Results[2]
Energy Management			
(α = 0.962)	Policy and objectives	0.926	1.77±1.20
	Operational knowledge	0.902	1.73±1.19
	Communication	0.876	1.43±1.24
	Performance measurement	0.721	2.05±0.96
	Analysis	0.796	1.42±0.98
Water management			
(α=0.916)	Policy and objectives	0.953	1.76±1.47
	Operational knowledge	0.921	1.87±1.14
	Communication	0.960	1.50±1.11
	Performance measurement	0.422	2.41±0.89
	Analysis	0.911	1.47±0.89
Waste management			
(α=0.959)	Policy and objectives	0.878	2.30±1.30
	Operational knowledge	0.890	2.09±1.13
	Communication	0.951	1.67±1.14
	Performance measurement	0.898	2.18±1.21
	Analysis	0.938	1.55±1.08
Waste water management			
(α=0.977)	Policy and objectives	0.920	1.94±1.44
	Operational knowledge	0.948	1.74±1.31
	Communication	0.936	1.42±1.24
	Performance measurement	0.933	1.85±1.37
	Analysis	0.935	1.21±1.21

[1] Eigenvalues were all greater than 1.0 and the cumulative variance explained was 85.8%.
[2] The Mean values ± Standard deviations were obtained from the raw data.

Table 4. Implementation level of environmental management

Category	N	PO	OK	CO	PM	AN
		Water usage				
Size						
Micro	7	0.69±0.51[a]	1.20±0.57[a]	0.71±0.19[a]	1.91±0.43[a]	1.11±0.54[a]
Small	12	0.95±0.93[a]	1.43±1.06[a]	0.93±0.82[a]	2.43±0.75[a]	1.11±0.67[a]
Big	11	3.33±0.92[b]	2.76±0.95[b]	2.61±0.81[b]	2.71±1.13[a]	2.20±0.84[b]
Certificates						
Yes	12	3.00±1.21[a]	2.65±0.999[a]	2.41±0.91[a]	2.57±1.06[a]	2.03±0.87[a]
No	18	0.93±0.96[b]	1.34±0.915[b]	0.89±0.77[b]	2.31±0.77[a]	1.10±0.70[b]
Meat sector						
Slaughter	17	2.10±1.51[a]	2.17±1.20[a]	1.85±1.11[a]	2.59±0.85[a]	1.64±0.86[a]
Meat processing	13	1.37±1.36[a]	1.51±0.98[a]	1.10±1.10[a]	2.21±0.92[a]	1.29±0.91[a]
		Energy usage				
Size						
Micro	7	1.17±0.37[a]	1.20±0.58[a]	0.74±0.43[a]	1.89±0.44[a,b]	1.03±0.21 [a]
Small	12	1.08±0.73[a]	1.23±1.05[a]	0.97±0.28[a]	1.63±0.47[b]	1.10±0.64[a]
Big	11	2.91±1.11[b]	2.60±1.16[b]	1.33±0.39[b]	2.62±1.31[a]	2.02±1.29[a]
Certificates						
Yes	12	2.52±1.12[a]	2.28±1.18[a]	2.02±1.34[a]	2.33±1.25[a]	1.83±1.16[a]
No	18	1.28±0.99[b]	1.36±1.07[b]	1.03±1.03[b]	1.87±0.67[a]	1.14±0.75[a]
Meat sector						
Slaughter	17	1.97±1.19[a]	1.96±1.27[a]	1.72±1.39[a]	2.16±1.09[a]	1.52±1.12[a]
Meat processing	13	1.54±1.20[a]	1.46±1.06[a]	1.08±0.98[a]	1.93±0.81[a]	1.30±0.81[a]
		Waste water discharge				
Size						
Micro	7	0.83±0.29[a]	0.80±0.60[a]	0.46±0.34[a]	0.83±0.60[a]	0.40±0.36[a]
Small	12	1.17±1.01[a]	1.18±1.12[a]	0.85±0.88[a]	1.15±0.94[a]	0.67±0.73[a]
Big	11	3.49±0.80[b]	2.94±0.88[b]	2.64±0.94[b]	3.25±0.89[b]	2.31±1.19[a]
Certificates						
Yes	12	3.18±0.99[a]	2.80±0.96[a]	2.52±0.95[a]	3.00±0.96[a]	2.13±1.17[a]
No	18	1.11±1.05[b]	1.03±0.99[b]	0.68±0.77[b]	1.08±1.03[b]	0.59±0.77[b]
Meat sector						
Slaughter	17	2.35±1.48[a]	2.15±1.37[a]	1.70±1.24[a]	2.30±1.32[a]	1.38±1.17[a]
Meat processing	13	1.47±1.29[a]	1.27±1.10[a]	1.09±1.20[a]	1.33±1.29[a]	1.00±1.25[a]
		Waste handling				
Size						
Micro	7	2.00±0.98[a]	1.43±0.60[a]	0.74±0.62[a]	1.34±0.36[a]	1.03±0.48[a]
Small	12	1.47±1.10[a]	1.60±0.92[a]	1.25±0.89[a]	1.73±1.23[a]	1.10±1.04[a]
Big	11	3.40±0.86[b]	3.05±0.98[b]	2.71±0.81[b]	3.20±0.78[b]	2.36±0.94[b]
Certificates						
Yes	12	3.18±0.93[a]	2.78±1.10[a]	2.42±0.74[a]	3.10±0.90[a]	2.27±1.01[a]
No	18	1.71±1.18[b]	1.63±0.98[b]	1.17±1.09[b]	1.57±0.98[b]	1.07±0.85[b]
Meat sector						
Slaughter	17	2.62±1.29[a]	2.41±1.24[a]	1.99±1.17[a]	2.69±1.19[a]	1.76±1.14[a]
Meat processing	13	1.93±1.25[a]	1.73±0.91[a]	1.30±1.03[a]	1.60±0.96[b]	1.30±0.99[a]

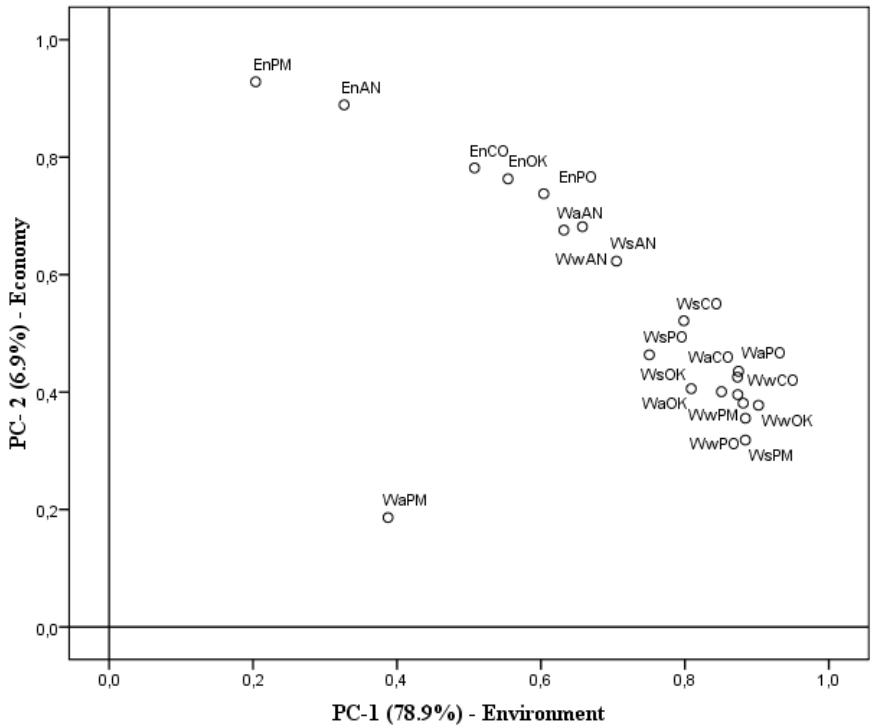
N – Sample size. The Mean values ± Standard deviations were obtained from the raw data

Explanation of score: 0 - 'no environmental management', 1 - 'some environmental management practice in place', 2 - 'environmental practice recognized by top management', 3 - 'environmental management is treated seriously by top management, 4 - 'full implementation of environmental management'

Explanation of abbreviations: PO - Policy and objectives; OK - Operational knowledge; CO - Communication: PM - Performance Measurement; AN - Analysis

Note: Items denoted with the same letter are not significantly different at the level of 5%.

a)



b)

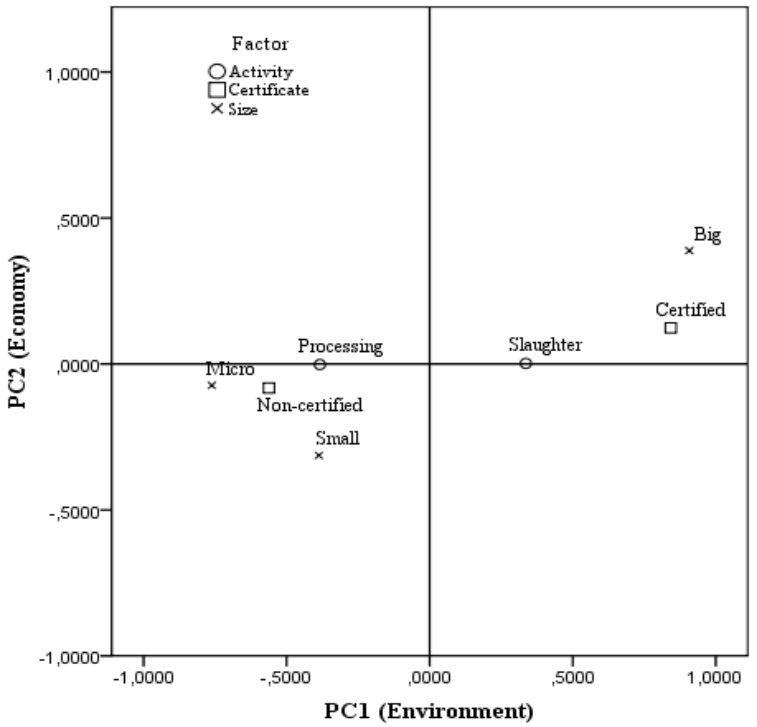


Figure 1. Principal component analysis loadings (a) and scores (b) plots for the 20 factors influencing environmental impact in meat companies in Serbia deployed by size of the companies, their activities and whether they hold any type of certificate. Rotation method: Varimix. The two extracted components explain 85.8 % of total variance.
En – Energy; Wa – Water; Ws – Waste; Ww – Waste water.
PO - Policy and objectives; OK - Operational knowledge; CO - Communication: PM - Performance Measurement; AN – Analysis.
Size – micro, small and big; Activity – slaughter, meat processing; Certificate status - certified and non-certified.

Highlights

- There is limited research on environmental practices in the meat chain
- Authors analyzed environmental practices in 30 meat companies in Serbia
- Slaughterhouses show better results compared to the meat processing plants
- Certified companies have better environmental practice than non-certified companies
- Large companies have better environmental practice than small and micro companies