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# WASTE GASES ARISING IN RENDERING PLANTS FOR ANIMAL AND FISH WASTE

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*Gases of disagreeable smell and those harmful to the external environment and working premises, arising during harmless removal of animal waste in rendering plants, have been investigated.*

*The waste gases in the Department (and equipment) for Raw Material Reception are generated by proteolytic destruction of raw material, which is promoted by tissue and bacteriological enzymes. In the processing department gases arise mostly under the influence of high temperatures during processing. During these procedures proteins and fats are broken down into ammonia, sulphurated hydrogen, sulphur dioxide, carbon dioxide, carbon monoxide, acrolein and some other identified gases of a pungent and unpleasant odour.*

*According to our investigations, in the Department for Raw Material Reception, near the tank for raw materials, the concentrations of ammonia (67,10 ppm), sulphurated hydrogen (19,40 ppm) and sulphur dioxide ( 11,60 ppm) were above the values for maximum allowable concentrations (M. A. C.) for the tested gases. The sulphur dioxide concentration was above the prescribed value for the MAC at all the measuring points in the same department.*

*In the Processing Department the highest concentration of ammonia, sulphurated hydrogen, sulphur dioxide, carbon dioxide and acrolein were found in the devices for Brud vapours condensation.*

*In the Department for Grinding and Bagging the obtained concentrations were under the prescribed MAC values.*

*As during rendering some harmful gases are released with concentrations above the MAC, it is absolutely essential to process exclusively fresh raw materials, as well as to maintain adequate hygiene of the unit and to install a system for conveying and purification of waste gases.*

*Key words: animal waste, harmless removal, waste gases, concentration, sources of pollution, environmental protection.*

## INTRODUCTION

The ever increasing demand for food production have created the need for more efficient management of economic resources. This has led to an increased worldwide interest in the use of waste material. Warnings have been issued concerning the impending dangers created by waste materials as environmental pollutants, threatening not only the health of humans but also of animals. One of the ways inedible animal offals can be used is processing them into animal feed. However, pollution of the environment, especially of the air, could result during processing of slaughterhouse by-products, fish waste and dead animals into animal feed, and products to be used in the chemical industry. Many authors have noticed the possibility of environmental pollution by waste material (Knop, 1975; Jelić et al., 1980; Ristić 1981; Kralj, 1984; Košmerl et al., 1989; Ristić et al., 1996). On the basis of their investigations it has been concluded that during animal waste processing not only are gases of a disagreeable odour released but also some noxious gases. In order to prevent their spreading within the surrounding area i. e. in order to create an appropriate microclimate, it is necessary to develop appropriate technologies for their purification.

The objective of this investigation was to identify the gases that might be present in units for rendering animal offal and also to determine the concentrations of some gases (that should not be above prescribed values) present in the external environment or in working premises.

## MATERIAL AND METHODS

Inedible slaughterhouse by - products and offals of pigs, dead animals and fish waste were subjected to dry batch rendering. The gas samples were collected by absorption pumps ("Casello") and absorption pumps for indicator capillaries.

Gas chromatography was applied in order to determine the kinds of gases and their concentrations.

The analyses were performed in five reprications and the results were statistically analyzed according to Hadživuković (1973).

The investigations included the identification of the noxious gases released during safe rendering of animal offals, as well as quantitative analysis of the gases whose concentrations are regulated by the regulations pertaining to the maximum allowable concentrations of noxious gases (JUS 2. BO 001, 1971).

The total gas identification was done after their emission from the production unit, whilst the quantitativ analysis of individual gases was made inside the departments and equipment for reception, transport and rendering of raw materials.

## RESULTS AND DISCUSSION

Further advancement in animal husbandry and the meat industry requires a solution of the problem of the so-called supporting technologies from the zoohygienic aspect, among which is the harmless processing of dead animals, fish waste and inedible slaughterhouse by-products into protein and energy feeds.

Most gases of unpleasant odour in rendering into protein and energy feeds.

Most gases of unpleasant odour in rendering plants originate from organic substances of animal origin and from their putrefaction. The most important sources of waste gases are:

- raw materials destroyed by proteolytic enzymes and microorganisms;
- machines and equipment, during processing;
-putrid remnants on the floor and within equipment;

waste waters of rendering;

- finished products.

The mentioned sources are in accordance with the findings of Jelić et al., 1980 and Ristić et al., 1987.

The kinds and concentrations of the gases released during rendering of raw materials of animal origin are presented in Tables 1 - 3.

Table 1. The identified gases released from rendering plants

| N° | Kind of gas | Chemical formula | Identified (+) |
|---|---|---|---|
| 1 | n – heksane | $C_6H_{14}$ | + |
| 2 | n – heptane | $C_7H_{16}$ | + |
| 3 | n – oktane | $C_8H_{18}$ | + |
| 4 | n – nonane | $C_9H_{20}$ | – |
| 5 | n – decane | $C_{10}H_{22}$ | – |
| 6 | n – undecane | $C_{11}H_{24}$ | – |
| 7 | dodecane | $C_{12}H_{26}$ | – |
| 8 | tridecane | $C_{13}H_{28}$ | – |
| 9 | 2-methylpentane | $C_6H_{14}$ | + |
| 10 | 3-methylhexsane | $C_7H_{16}$ | + |
| 11 | methylcyclopentane | $CH_3C_5H_9$ | + |
| 12 | cuclohexane | $C_6H_{12}$ | + |
| 13 | methylcyclopentane | $CH_3C_6H_{11}$ | + |
| 14 | propanthiol | $C_3H_7SH$ | + |
| 15 | butanthiol | $C_4H_9SH$ | + |
| 16 | benzene | $C_6H_6$ | + |
| 17 | ethylbenzene | $C_6H_5C_2H_5$ | + |
| 18 | toluol | $C_7H_8$ | + |
| 19 | o-m-p-xulene | $(CH_3)_2C_6H_4$ | + |
| 20 | ammonia | $NH_3$ | + |
| 21 | trimethylamine | $(CH_3)_3NH_2$ | + |
| 22 | sulphurated hydrogen | $H_2S$ | + |
| 23 | sulphur dioxide | $SO_2$ | + |
| 24 | carbon dioxide | $CO_2$ | + |
| 25 | carbon monoxide | $CO$ | + |
| 26 | acrolein | $CH_2CHCHO$ | + |

The identified gases, presented on Table 1. are of disagreeable odour, and have an adverse effect on the unit, its equipment and the health of people.

The results pertaining to the gas concentrations in the receiving department (Table 2) showed statistically significant differences (p < 0,05) among the ammonia concentrations with regard to the place where the samples were collected.

Table 2. Statistical analysis of concentrations of gases released from the Department for Raw Material Reception

| Kind of gas (ppm) | Place ofsampling | n | X̄ | S | c | F-test (0,05) Exp. | Tab. |
|---|---|---|---|---|---|---|---|
| Ammonia | 1. Tank for receiving the raw materials | 5 | 67,10 | 3,30 | 4,91 | 670,30 | 3,24 |
| | 2. Cinveying belt with metal detector | 5 | 29,86 | 1,77 | 5,93 | | |
| | 3. Crusing machine | 5 | 21,05 | 1,13 | 5,35 | | |
| | 4. Department for raw material reception | 5 | 8,02 | 0,69 | 8,57 | | |
| Sulphurated hydroxide | 1. Tank for receiving the raw materials | 5 | 19,40 | 1,08 | 5,57 | 805,37 | 3,24 |
| | 2. Cinveying belt with metal detector | 5 | 2,98 | 0,21 | 6,93 | | |
| | 3. Crusing machine | 5 | 3,02 | 0,11 | 3,76 | | |
| | 4. Department for raw msterial reception | 5 | 3,97 | 0,25 | 6,40 | | |
| Sulphur dioxide | 1. Tank for receiving the raw materials | 5 | 11,60 | 0,37 | 3,19 | 682,99 | 3,24 |
| | 2. Cinveying belt with metal detector | 5 | 12,00 | 0,42 | 3,47 | | |
| | 3. Crusing machine | 5 | 12,10 | 0,72 | 5,96 | | |
| | 4. Department for raw msterial reception | 5 | 0,00 | 0,00 | 0,00 | | |
| Carbon dioxide | 1. Tank for receiving the raw materials | 5 | 1724,2 | 129,09 | 7,49 | 353,49 | 3,24 |
| | 2. Cinveying belt with metal detector | 5 | 438,5 | 28,23 | 6,44 | | |
| | 3. Crusing machine | 5 | 449,1 | 34,17 | 7,61 | | |
| | 4. Department for raw msterial reception | 5 | 347,0 | 30,94 | 8,92 | | |
| Carbon monoxide | 1. Tank for receiving the raw materials | 5 | 5,80 | 0,37 | 6,29 | 0,076 | 3,24 |
| | 2. Cinveying belt with metal detector | 5 | 5,90 | 0,49 | 8,37 | | |
| | 3. Crusing machine | 5 | 5,80 | 0,38 | 6,60 | | |
| | 4. Department for raw msterial reception | 5 | – | – | – | | |

Key: n = number of recordings X = mean value
s = standard deviation c = coefficient of variation

The highest ammonia concentration (67,10 ppm) was recorded in the receiving tank, as was expected, due to the proteolytic processes promoted there by tissue and bacteriological enzymes. The emitted gases, due to the closed space (the tank with a cover), had the highest concentration and over pressure at aspiration channels. The ammonia concentration at the other places (the conveying belt, the crushing machine and the air from the Department for Raw Material Reception) were lower due to rarefaction. The difference in the sulphurated hydrogen concentrations near the conveying belt with metal detector and the crushing machine was not statistically significant; whereas the differences in the ammonia concentration in the receiving tank compared with the other tested places was statistically significant.

The sulphur dioxide concentrations in the receiving tank, crushing machine and near the conveying belt were statistically significant in relation to the sulphur dioxide concentration in the Department for Raw Material Reception. The remaining differences in the sulphur dioxide concentrations in the same department were not statistically significant. Such results were brought about by the position of the receiving tank, the conveying belt and the crushing machine, which were situated 5 m below the Department for Raw Material Reception, thus enabling an accumulationof sulphur dioxide due to its higher specific mass compared to the air.

The above gases are of a very unpleasant odour that can be perceived in the investigated premises. The obtained results are in agreement with those obtained by Ristić et al., 1987, and Košmerl et al., 1989. Many authors (Kurmier, 1973, Flemiech, 1974; Knop, 1975; Jelić et al., 1980; Kralj, 1984.) have destected higher concentrations of the noxious gases of very intensive unpleasant smell in the Department for Raw Material Reception, regardless of the size of the unit and the construction of the receiving tank.

The differences in the carbon dioxide and carbon monoxide concentrations in the Department for Raw Material Reception, regardless of the place of sampling, ware not statistically significant, except for the differences concerning carbon dioxide in the receiving tank compared to the other places. From the aspect of the maximum allowable concentrations of noxious gases, vapours and aerosols in the atmosphere at working premises, the receiving tank presents a major problem, as the levels of ammonia (67,10 ppm), sulphurated hydrogen (19,40 ppm) and sulphur dioxide (11,60) exceed the MAC values as prescribed both in our country and throughout the world (Sax, 1975; Wallace, 1978; Preregud, 1978). According to these standards the allowed concentrations are: for ammonia 50 ppm (Yu, Germany), 28 ppm (Russia) and 25 ppm (USA); and for suphurated hydrogen 10 ppm (Germany, USA), 7 ppm (Yu, Russia); and for sulphur dioxide 5 ppm (Germany, USA), 4 ppm (Yu, Russia).

As the sulphur dioxide concentration exceeded the upper limit of the MAC at all the measuring points, it represents a grave danger to the health of the people working there, due to its acute toxic effect. Moreover, sulphur dioxide corrodes the equipment and the plant itself, thus endangering the measuring instruments and automatic regulation.

The recorder concentrations for the remaining investigated gases were lower than the allowed ones. However, the gases have unpleasant smells and are detrimental to human health. This unpleasant smell of ammonia, sulphurated hydrogen and sulphur dioxide occur at very low temperatures, i. e.: ammonia 0,037 ppm, sulphurated hydrogen 0,01 ppm and sulphur dioxide 0,037 ppm.

The gases released in the processing department, resulting from the decay of organic matter (especially proteins and fats) mostly under the influence of the high processing temperature, are shown in Table 3.

Table 3. Statistical analysis of concentrations of gases released in the Processing Department

| Kind of gas (ppm) | Place of sampling | n | $\overline{X}$ | S | c | F-test (0,05) Exp. | Tab. |
|---|---|---|---|---|---|---|---|
| Ammonia | 1. Devices for Brüd vapours condensation | 5 | 39,26 | 0,32 | 3,97 | 634,59 | 3,24 |
| | 2. Fat separator | 5 | 7,96 | 0,16 | 3,61 | | |
| | 3. Press exit channel | 5 | 4,32 | 2,79 | 7,11 | | |
| | 4. Grunding department | 5 | 0,70 | 0,06 | 7,93 | | |
| Sulphurated hydrogen | 1. Devices for Brüd vapours condensation | 5 | 7,81 | 0,39 | 5,01 | 640,00 | 3,24 |
| | 2. Fat separator | 5 | 3,31 | 0,21 | 6,43 | | |
| | 3. Press exit channel | 5 | 2,41 | 0,20 | 8,32 | | |
| | 4. Grunding department | 5 | 0,50 | 0,04 | 7,48 | | |
| Suiphur dioxide | 1. Devices for Brüd vapours condensation | 5 | 2,70 | 0,25 | 9,29 | 203,97 | 3,24 |
| | 2. Fat separator | 5 | 2,05 | 0,13 | 6,26 | | |
| | 3. Press exit channel | 5 | 2,30 | 0,19 | 8,10 | | |
| | 4. Grunding department | 5 | 0,00 | 0,00 | 0,00 | | |
| Carbon dioxide | 1. Devices for Brüd vapours condensation | 5 | 886,15 | 39,01 | 4,40 | 2292,97 | 3,24 |
| | 2. Fat separator | 5 | 438,20 | 19,97 | 4,56 | | |
| | 3. Press exit channel | 5 | 298,00 | 11,32 | 3,80 | | |
| | 4. Grunding department | 5 | 272,00 | 21,67 | 7,97 | | |
| Acrolein | 1. Devices for Brüd vapours condensation | 5 | 1,01 | 0,05 | 5,35 | 2749,70 | 3,24 |
| | 2. Fat separator | 5 | 1,34 | 0,05 | 3,53 | | |
| | 3. Press exit channel | 5 | 0,35 | 0,02 | 5,11 | | |
| | 4. Grunding department | 0 | 0,00 | 0,00 | 0,00 | | |

Key: n = namber of recordings X = mean value
S = standard deviation c= coefficient of variation

The results presented in Table 3 show that, during processing of raw materials of animal origin into meat and bone meal, ammonia is released at all the tested points, its concengrations being statistically significantly. The highest ammonia and sulphurated hydrogen concentrations were recorded in the vicinity of the devices for Brud vapours condensation, as stated by Kosmerl et al. 1989. Such high concentrations are the result of the high sterilization temperature (133$^{0}$C; 30 min) which affects thermolysis of the raw materials. The lowest ammonia concentration was recorded in the Department for grinding and bagging of the final products, due to its complete isolation from other processing departments.

Overall the results presented in Table 3 indicate that the concentrations of the tested gases, except for the sulphurated hydrogen concentration near the devices for Brüd vapours condenstation, were lower than the prescribed MAC values for each gas separately.

The acrolein concentrations at the measuring points exceeded the prescribed values of 0,25 mg/m$^3$ (Yu, Germany), and 0,20 mg/m$^3$ (Russia), this being extremely dangerous, as acrolei;n has acute toxic effects during protracted inhaling.

According to the norms (set in Germany) concerning environmental protection, the waste gas concentration in plants for processing animal offal into meat and bone meal must not exceed 20 mg/m$^3$ (Košmerl et al., 1989).

In order to prevent the spreading of harmful gases into the surrounding area and environmental pollution, to preserve an adequate microclimate, fresh raw materials should be processed exclusively, at the same time, adequate sanitary measures in the unit and its equipment and installing a system for conveying and purification of waste gases.

## CONCLUSION

On the basis of this investigation of waste gases released during processing of animal offal into protein and energy feed it can be concluded the considerable quantities of waste gases (both harmful gases and those of unpleasant smell) are emitted (ammonia 67,10 ppm, sulphurated hydrogen 21,50 ppm and sulphur dioxide 12,30 ppm).

The investigations pointed to the receiving tank and the devices for Brüd vapours condensation as places that present a special danger.

Therefore, it is indispensable to gather, transport and process such materials as soon as possible, as well as to collect and purify the released gases (incineration, biological treatment, chemical treatment).

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## OTPADNI GASOVI KOJI NASTAJU U POGONIMA ZA NEŠKODLJIVO UKLANJANJE ANIMALNIH OTPADAKA TEHNIČKOM PRERADOM

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SADRŽAJ

U radu su ispitivani neprijatni i po životnu i radnu sredinu štetni gasovi koji se stvaraju tokom tehnoloških procesa neškodljivog uklanjanja animalnih otpadaka tehničkom preradom.

Otpadni gasovi u odeljenju i uređajima za prijem sirovina nastaju proteolitičkom razgradnjom sirovina, koja se odvija dejstvom enzima tkiva i bakterioloških enzima. U odeljenju za preradu sirovina gasovi uglavnom nastaju pod uticajem visokih temperatura procesa. U ovim procesima razgrađuju se proteini i masti, pri čemu nastaju amonijak, sumporvodonik, sumpordioksid, ugljendioksid, ugljenmonoksid, akrolein i drugi identifikovani gasovi veoma jakih i neprijatnih mirisa.

U odeljenju za prijem sirovina kod rezervoara za prihvat sirovina koncentracije amonijaka (67,10 ppm), sumporvodonika (21,50 ppm) i sumpordioksida (12,30 ppm) su bile iznad vrednosti MDK za ispitivane gasove. Koncentracije sumpordioksida su bile iznad propisane vrednosti MDK za sumpordioksid i kod ostalih mernih punktova u istom odeljenju.

U odeljenju za preradu sirovina najviše koncentracije amonijaka, sumporvodonika, sumpordioksida, ugljendioksida i akroleina su kod nekondenzovanih Brüd-ovih para.

U odeljenju za mlevenje i homogenizaciju utvrđene koncentracije gasova su ispod propisanih MDK vrednosti.