



## WASTE GASES ARISING IN RENDERING PLANTS FOR HARMLESS REMOVAL OF ANIMAL BY-PRODUCTS BY TECHNOLOGICAL PROCESSING

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### ABSTRACT

Gases of disagreeable smell and those harmful to the external environment and working premises, arising during harmless removal of animal waste in rendering plants (in the Department for Raw Material Reception, in the Processing Department and in the Department for Grinding and Bagging) have been investigated.

According to our investigations, in the Department for Raw Material Reception, near the tank for raw material, 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 (MAC) 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 the devices for Brüd 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 in the concentrations above the MAC, it is absolutely essential to process exclusively fresh material, as well as to maintain adequate hygiene of the unit and to install a system for conveying and purification of waste gases.

### 1. 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 material 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 [1-5].

On the basis of their investigations it has been concluded that during animal waste processing not only are gases of 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.

## **2. MATERIALS 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 replications and the results were statistically analyzed according to Hadživuković [6].

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 [7].

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

## **3. 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 plants originate from organic substances of animal origin and from their putrefaction. The most important sources of waste gases are:

- raw material destroyed by proteolytic enzymes and microorganisms;
- machines and equipment during processing;

- putrid remnants on the floor and within equipment;
- waste water of rendering;
- finished products.

The mentioned sources are in accordance with the findings of Jelić and co-workers [1] and Ristić and co-workers [8].

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

The identified gases, presented in 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 1. THE IDENTIFIED GASES RELEASED FROM RENDERING PLANTS

N <sup>o</sup>	KIND OF GAS	CHEMICAL FORMULA	IDENTIFIED (+)
1	n-hexane	C <sub>6</sub> H <sub>14</sub>	+
2	n-heptane	C <sub>7</sub> H <sub>16</sub>	+
3	n-oktane	C <sub>8</sub> H <sub>18</sub>	+
4	n-nonane	C <sub>9</sub> H <sub>20</sub>	-
5	n-decane	C <sub>10</sub> H <sub>22</sub>	-
6	n-undecane	C <sub>11</sub> H <sub>24</sub>	-
7	dodecane	C <sub>12</sub> H <sub>26</sub>	-
8	tridecane	C <sub>13</sub> H <sub>28</sub>	-
9	2-methylpentane	C <sub>6</sub> H <sub>14</sub>	+
10	3-methylhexane	C <sub>7</sub> H <sub>16</sub>	+
11	methylcyclopentane	CH <sub>3</sub> C <sub>5</sub> H <sub>9</sub>	+
12	cyclohexane	C <sub>6</sub> H <sub>12</sub>	+
13	methylcyclopentane	CH <sub>3</sub> C <sub>6</sub> H <sub>11</sub>	+
14	propanthiol	C <sub>3</sub> H <sub>7</sub> SH	+
15	butanthiol	C <sub>4</sub> H <sub>9</sub> SH	+
16	benzene	C <sub>6</sub> H <sub>6</sub>	+
17	ethylbenzene	C <sub>6</sub> H <sub>5</sub> C <sub>2</sub> H <sub>5</sub>	+
18	toluol	C <sub>7</sub> H <sub>8</sub>	+
19	o-m-p-xylene	(CH <sub>3</sub> ) <sub>2</sub> C <sub>6</sub> H <sub>4</sub>	+
20	ammonia	NH <sub>3</sub>	+
21	trimethylamine	(CH <sub>3</sub> ) <sub>3</sub> NH <sub>2</sub>	+
22	sulphurated hydrogen	H <sub>2</sub> S	+
23	sulphur dioxide	SO <sub>2</sub>	+
24	carbon dioxide	CO <sub>2</sub>	+
25	carbon monoxide	CO	+
26	acrolein	CH <sub>2</sub> CHCHO	+

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 were statistically significant.

TABLE 2. STATISTICAL ANALYSIS OF CONCENTRATIONS OF GASES RELEASED FROM THE DEPARTMENT FOR RAW MATERIAL RECEPTION

KIND OF GAS (ppm)	PLACE OF SAMPLING	$n^1$	$\xi^2$	$s^3$	$c^4$	F-test (0.05)	
						Exp.	Tab.
Ammonia	1. Tank for receiving the raw material	5	67.10	3.30	4.91	670.30	3.24
	2. Conveying belt with metal detector	5	29.86	1.77	5.93		
	3. Crushing machine	5	21.05	1.13	5.35		
	4. Department for raw material reception	5	8.02	0.69	8.57		
Sulphurated hydrogen	1. Tank for receiving the raw material	5	19.40	1.08	5.57	805.37	3.24
	2. Conveying belt with metal detector	5	2.98	0.21	6.93		
	3. Crushing machine	5	3.02	0.11	3.76		
	4. Department for raw material reception	5	3.97	0.25	6.40		
Sulphur dioxide	1. Tank for receiving the raw material	5	11.60	0.37	3.19	682.99	3.24
	2. Conveying belt with metal detector	5	12.00	0.42	3.47		
	3. Crushing machine	5	12.10	0.72	5.96		
	4. Department for raw material reception	5	0.00	0.00	0.00		
Carbon dioxide	1. Tank for receiving the raw material	5	1724.2	129.09	7.49	353.49	3.24
	2. Conveying belt with metal detector	5	438.5	28.23	6.44		
	3. Crushing machine	5	449.1	34.17	7.61		
	4. Department for raw material reception	5	347.0	30.94	8.92		
Carbon monoxide	1. Tank for receiving the raw material	5	5.80	0.37	6.29	0.076	3.24
	2. Conveying belt with metal detector	5	5.90	0.49	8.37		
	3. Crushing machine	5	5.80	0.38	6.60		
	4. Department for raw material reception	5	-	-	-		

$n^1$  – number of recordings

$s^3$  – standard deviation

$\xi^2$  – mean value

$c^4$  – coefficient of variation

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 accumulation of 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 and co-workers [8] and Košmerl and co-workers [9].

Many authors [1,2, 4] have detected 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, were 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 [10].

According to these standards the allowed concentrations are: for ammonia 50 ppm (Serbia and Montenegro, Germany), 28 ppm (Russia) and 25 ppm (USA); for sulphurated hydrogen 10 ppm (Germany, USA) and 7 ppm (Serbia and Montenegro, Russia); for sulphur dioxide 5 ppm (Germany, USA) and 4 ppm (Serbia and Montenegro, Russia).

As the sulphur dioxide concentration exceeded the upper limit of the MAC at all the measuring points, it represents a great 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 smell and are detrimental to human health. This unpleasant smell of ammonia, sulphurated hydrogen and sulphur dioxide occurs 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.

The results presented in Table 3 show that during processing of raw material of animal origin into meat and bone meal ammonia is released at all the tested points, its concentrations being statistically significant.

The highest ammonia and sulphurated hydrogen concentrations were recorded in the vicinity of the devices for Brüd vapours condensation, as stated by Košmerl and co-workers [9].

Such high concentrations are the result of the high sterilization temperature (133 °C; 30 min) which affects thermolysis of the raw material. 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 condensation, were lower than the prescribed MAC values for each gas separately.

The acrolein concentrations at the measuring points exceeded the prescribed values of  $0.25 \text{ mg/m}^3$  (Serbia and Montenegro, Germany) and  $0.20 \text{ mg/m}^3$  (Russia), this being extremely dangerous, as acrolein 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  $20 \text{ mg/m}^3$  [9].

TABLE 3. STATISTICAL ANALYSIS OF CONCENTRATIONS OF GASES RELEASED IN THE PROCESSING DEPARTMENT

KIND OF GAS (ppm)	PLACE OF SAMPLING	$n^1$	$\xi^2$	$s^3$	$c^4$	F-test (0.05)	
						Exp.	Tab.
Ammonia	1. Devices for Brüd vapours condensation	5	39.26	0.32	3.97		
	2. Fat separator	5	7.96	0.16	3.61	634.59	3.24
	3. Press exit channel	5	4.32	2.79	7.11		
	4. Grinding department	5	0.70	0.06	7.93		
Sulphurated hydrogen	1. Devices for Brüd vapours condensation	5	7.81	0.39	5.01		
	2. Fat separator	5	3.31	0.21	6.43	640.00	3.24
	3. Press exit channel	5	2.41	0.21	8.32		
	4. Grinding department	5	0.50	0.04	7.48		
Sulphur dioxide	1. Devices for Brüd vapours condensation	5	2.70	0.25	9.29		
	2. Fat separator	5	2.05	0.13	6.26	203.97	3.24
	3. Press exit channel	5	2.30	0.19	8.10		
	4. Grinding department	5	0.00	0.00	0.00		
Carbon dioxide	1. Devices for Brüd vapours condensation	5	886.15	39.01	4.40		
	2. Fat separator	5	438.20	19.97	4.56	353.49	3.24
	3. Press exit channel	5	298.00	11.32	3.80		
	4. Grinding department	5	272.00	21.67	7.97		
Acrolein	1. Devices for Brüd vapours condensation	5	1.01	0.05	5.35		
	2. Fat separator	5	1.34	0.05	3.53	2749.70	3.24
	3. Press exit channel	5	0.35	0.02	5.11		
	4. Grinding department	5	-	-	-		

$n^1$  – number of recordings

$\xi^2$  – mean value

$s^3$  – standard deviation

$c^4$  – coefficient of variation

In order to prevent the spreading of harmful gases into the surrounding area and environmental pollution, to preserve an adequate microclimate, fresh raw material 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.

#### 4. CONCLUSIONS

On the basis of this investigation of waste gases released during processing of animal offal into protein and energy feeds it can be concluded that 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 investigation 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 material as soon as possible, as well as to collect and purify the released gases (incineration, biological treatment, chemical treatment).

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