

# TASTE AND SMELL PERCEPTION AMONG SEWAGE TREATMENT AND LANDFILL WORKERS

KAROLINA DŹAMAN, ANDRZEJ WOJDAS, PIOTR RAPIEJKO, and DARIUSZ JURKIEWICZ

Military Institute of Medicine, Warszawa, Poland

Department of Otolaryngology

## Abstract

**Objectives:** The study investigated the functioning of the taste and smell senses in workers employed at a sewage treatment plant and waste landfill. **Materials and Methods:** The study population was divided into three groups: sewage workers (group 1), landfill workers (group 2), and laboratory workers (group 3). Smell sensation was assessed using the Börstein gustometry method and taste sensation the Elsberg-Levy olfactometry method. The examinations were performed before and after working hours. **Results:** Taste disorders were noted in nearly 20% of subjects in each study group examined before work, and in 50% (group 1), 40% (group 2), 28.4% (group 3) of workers examined after work. As regards the sweet taste, a statistically higher value of the mean taste perception threshold (TPT) could be noted in each group examined before work compared to the control group. This referred also to salty taste in groups 1 and 2 and to bitter taste in groups 1 and 3. In the examinations carried out after work, all average TPTs increased and were statistically significant in relation to the sour and bitter tastes in group 1 and to sour taste in group 2. Smell examinations before and after work showed a statistically higher value of the mean olfactory perception threshold (OPT) for each odour than in the control group. The increase in the mean OPT after work was not statistically significant and did not differ between the groups. Before work, the percentage of workers with smell disorders amounted to 31.5% in the group of sewage workers, 6.3% of laboratory workers and 21.7% of landfill workers. After the working hours, these values increased to 40%, 8% and 38.4%, respectively. **Conclusions:** The study results indicate a higher risk of smell and taste dysfunctions among workers at a sewage treatment plant and waste landfill. The perception of the sour taste appeared to be most sensitive after short-term exposure but this dysfunction is probably reversible in nature. Other tastes were more sensitive to chronic toxic exposure than the sour taste.

## Key words:

Smell, Taste, Sewage, Landfill, Waste

## INTRODUCTION

An increased interest has recently been noted with respect to the possible health effects of hazardous exposure of workers at sewage plants and landfills. In these workplaces, the workers are permanently exposed to various, potentially harmful, chemical and biological agents. Among the hazardous agents emitted during waste management, there are organic compounds, heavy metals, polychlorinated biphenyls, and dioxins [1–4]. Landfill workers are particularly exposed to gases such as methane, carbon dioxide and sulphur dioxide.

As regards the biological agents, an increased concentration of bacteria, fungi, viruses, protozoans, microorganisms,

and organic dusts, including among others endotoxins and glucans, has been observed in both workplaces [4–9].

The specific character of work in the municipal waste and water treatment plant is connected with workers' exposure to irritants, sensitizing agents, toxicants and other substances which often have an unpleasant odour. The degree of exposure varies depending on the stage of processing the sewage and waste. The most frequently diagnosed diseases resulting from exposure to hazardous agents from sewage sludge and solid waste include rhinitis, pharyngitis, conjunctivitis, allergic pulmonary alveolitis, diarrhoea and other infections of the gastrointestinal system, as well as damages to the central nervous system [4,10–12]. The upper respiratory tract is particularly

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Address reprint request to: K. Dżaman, Department of Otolaryngology, Military Institute of Medicine, Szaserów 128, 09-900 Warszawa, Poland (e-mail: kfrydel@poczta.onet.pl).

exposed to the activity of hazardous agents. The workers at sewage treatment plants and landfills often complain about malaise, cough, breathing problems as well as of an unpleasant taste in the mouth and dysgeusia (taste disorder) [4,11,13–14]. Despite the fact that the workers have been complaining about abnormal function of their senses, no studies have thus far evaluated the taste and smell perception in this profession. Therefore, the aim of the present project was to assess the functioning of the taste and smell senses among sewage treatment plant and landfill workers exposed to biological and chemical hazards in workplace.

## MATERIALS AND METHODS

The study was conducted among 57 workers at the Municipal Service Co. in Chelm, Poland. A combined sewage treatment plant is located there that employs both mechanical and biological treatment technologies and has a throughput approximating 19 000 m<sup>3</sup>/day. The study population was divided into three subgroups according to the kind of exposure: sewage workers (23 persons — group 1), landfill workers (19 persons — group 2), laboratory workers (15 persons — group 3) (Table 1). The control group comprised 51 healthy volunteers working under no exposure to toxic agents in workplace. The members of this group have been working mainly in a hospital and had

no contact with agents that could affect the function of the smell and taste senses.

The subjects' age ranged from 25 to 55 years (mean 40.9) and the employment duration from 0.5 to 34 years (mean 13.4). About 31% of the subjects reported tobacco smoking, with the average number of 11 cigarettes smoked daily (5–30 cigarettes/day). The workers included in the study were only those who had no major anatomical changes of nasal and oral cavities at a laryngological examination and who showed no symptoms of infection on the day of examination. The exclusion criteria were also the diseases that could affect the taste and smell perception. Smell was assessed using the Börstein gustometry method, and taste the Elsberg-Levy olfactometry method [15–17]. The examinations were performed before and after the working hours (8 h).

The sense of taste was evaluated using four substances related to the four basic tastes: sweet (glucose: 5%, 10%, 20%), bitter (chininum hydrochloride: 0.075%, 0.5%, 1%), sour (citric acid: 1%, 5%, 10%) and salty (sodium chloride: 2.5%, 7.5%, 15%). The taste perception threshold (TPT) for each taste was regarded as the lowest concentration of each solution at which a given taste could be felt. Basing on reference values we diagnosed normogeusia (correct taste perception) if the worker felt taste at the lowest concentration specified [15,17]. Hypogeusia was diagnosed if the worker

**Table 1.** Characteristics of the study population

Parameter	Workplace			Controls
	Water treatment plant (group 1)	Landfill (group 2)	Laboratory (group 3)	
Number of persons	23	19	15	51
Gender (n)				
Female	0	0	15	25
Male	23	19	0	26
Age average (years)	41 (25–55)	37 (25–45)	44.9 (26–54)	37.71 (18–62)
Average time of work (years)	15.3 (0.5–34)	9.9 (3–16)	15 (0.5–30)	14 (1–29)
Smokers (%)	34.8	31.5	26.7	31.4
Subjective taste dysfunctions (n)	0	0	3.0	0
Subjective smell dysfunctions (n)	5.0	0	3.0	0

n — number of persons.

could feel taste at the other two concentrations and ageusia if he did not feel any taste at any of the concentrations studied.

At the assessment of the olfactory sense, air containing each of the four odours: vanilla, coffee, mint and lemon, was insufflated into the nasal cavity. The vanilla and coffee odours activate mainly the olfactory nerve and the mint and lemon odours stimulate both the olfactory and trigeminal nerves. The olfactory perception threshold (OPT) for each odour was regarded as the volume of insufflated air at which the worker could feel any odour. Using the reference values we diagnosed normosmia (correct smell sense) when the worker could feel odour at insufflating 1 to 10 cm<sup>3</sup> of air with vanilla, mint and lemon odour and 1 to 14 cm<sup>3</sup> of air with coffee odour [17]. If the olfactory perception threshold was lower than 40 cm<sup>3</sup>, but higher than normosmia, we diagnosed hyposmia. In this method, anosmia is diagnosed above 40 cm<sup>3</sup>. Before the onset of the examinations, the workers were asked to complete a questionnaire for a self-assessment of their taste and smell senses.

### Statistical analysis

The Kolmogorov-Smirnov test was applied to check for the normal distribution. The normal distribution was adopted for the test results  $K-S d \in (0.2-0.4)$ . In the statistical analysis, the Pearson product-moment correlation coefficient and Student-t test were used both for the dependent and independent variables. Statistical analysis was performed using STATISTICA-6pl software, with the level of significance set at  $\alpha < 0.05$ .

During the gustometric examination, we noted that some people did not feel any taste at any concentration of the solution. They were diagnosed with ageusia. In these cases, the taste perception threshold was described as 150% of the highest concentration of the solution (e.g. 30% glucose or 1.5% chininum hydrochloride). During olfactometry, we did not observe any persons with anosmia.

The study was approved by the Bioethical Committee, Military Institute of Medicine, Warszawa, Poland.

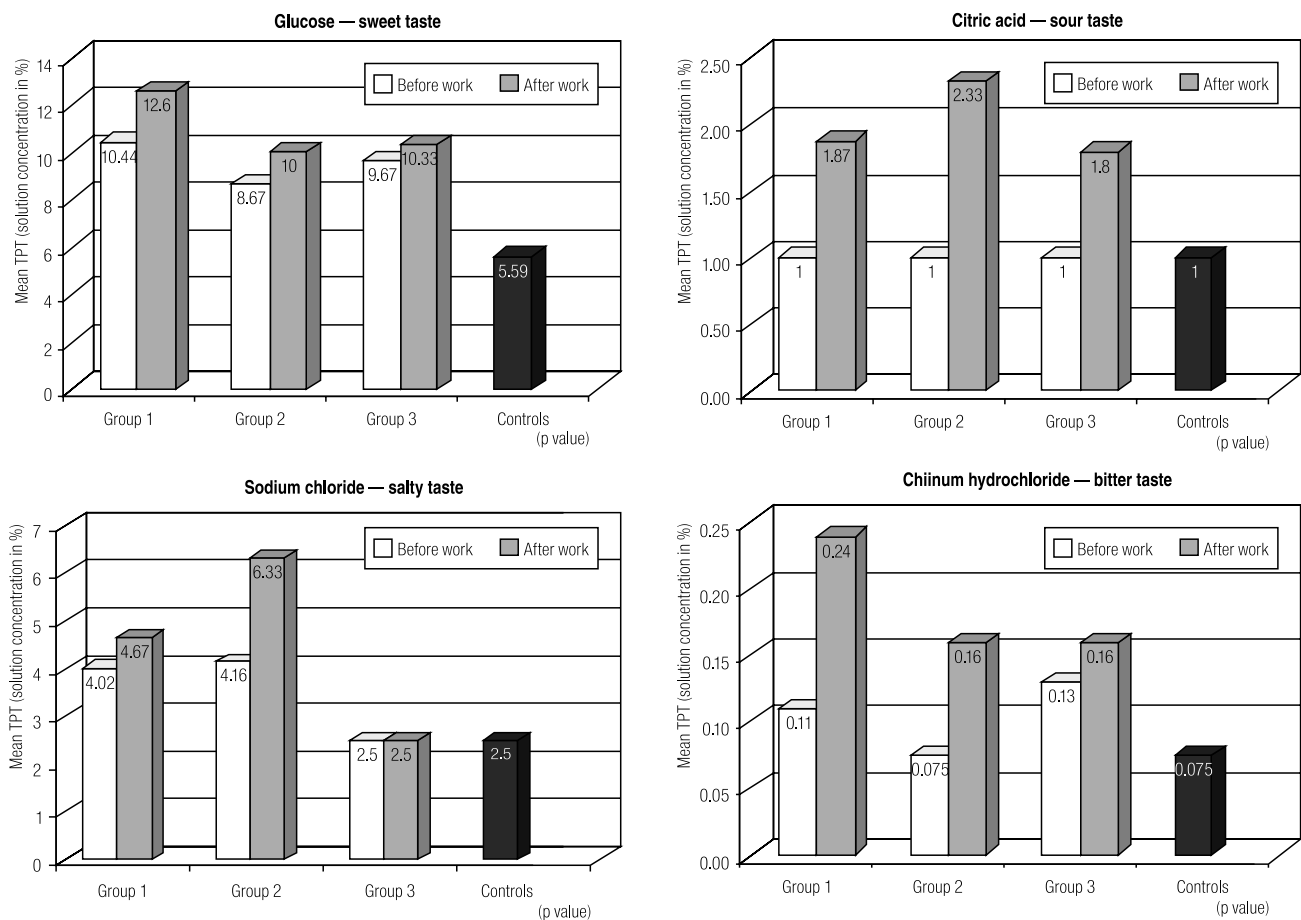
## RESULTS

The gustometric examination performed before work revealed taste disorders in 22% of sewage workers and 17% of laboratory workers and landfill workers. In the examinations carried out after working hours, the percentage of workers with incorrect taste perception increased to 50% among sewage workers, 28.4% laboratory workers and 40% landfill workers.

The increase in the perception threshold of the sweet taste was the most frequent finding. In each of the subgroups, the mean TPT for the sweet taste differed from the results obtained in the control group. The sour taste was the only taste whose perception was correct in the three subgroups and comparable to that recorded for the control group before work (Fig. 1). Gustometry performed after 8-hour work shift, showed an increase in the average TPT for each taste, but the changes were statistically significant only with respect to the sour and bitter tastes in the group of sewage workers and to the sour taste in landfill workers (Fig. 1). Among the laboratory workers, the changes in the mean TPT after work were not statistically significant for any of the tastes. Gustometry performed after work among sewage workers and landfill workers showed abnormal TPT values in relation to all the four tastes examined. The results of assessment of the sweet and bitter tastes in laboratory workers remained similar to those recorded before work.

The olfactory sense examination that had been performed before the onset of work revealed an increased OPT in each group with respect to all the odours (Fig. 2). The results differed statistically from the findings obtained for the control group.

Coffee and lemon OPTs were higher for the sewage workers and landfill workers than for the laboratory workers ( $p < 0.05$ ). Before work, the average percentage of workers with smell perception disorders amounted to 31.5% among sewage workers, 6.3% laboratory workers and 21.7% landfill workers. In the examinations conducted after work, the average percentage of workers who did not perceive odours correctly increased to about 40%



Group 1 — Sewage workers, Group 2 — Landfill workers, Group 3 — Laboratory workers. The mean TPT is the mean of all TPT measurements for each substance in a given group.

**Fig. 1.** Comparison of mean taste perception thresholds (TPT) before and after work in particular study groups.

in the group of sewage workers, 8% laboratory workers and 38.4% landfill workers.

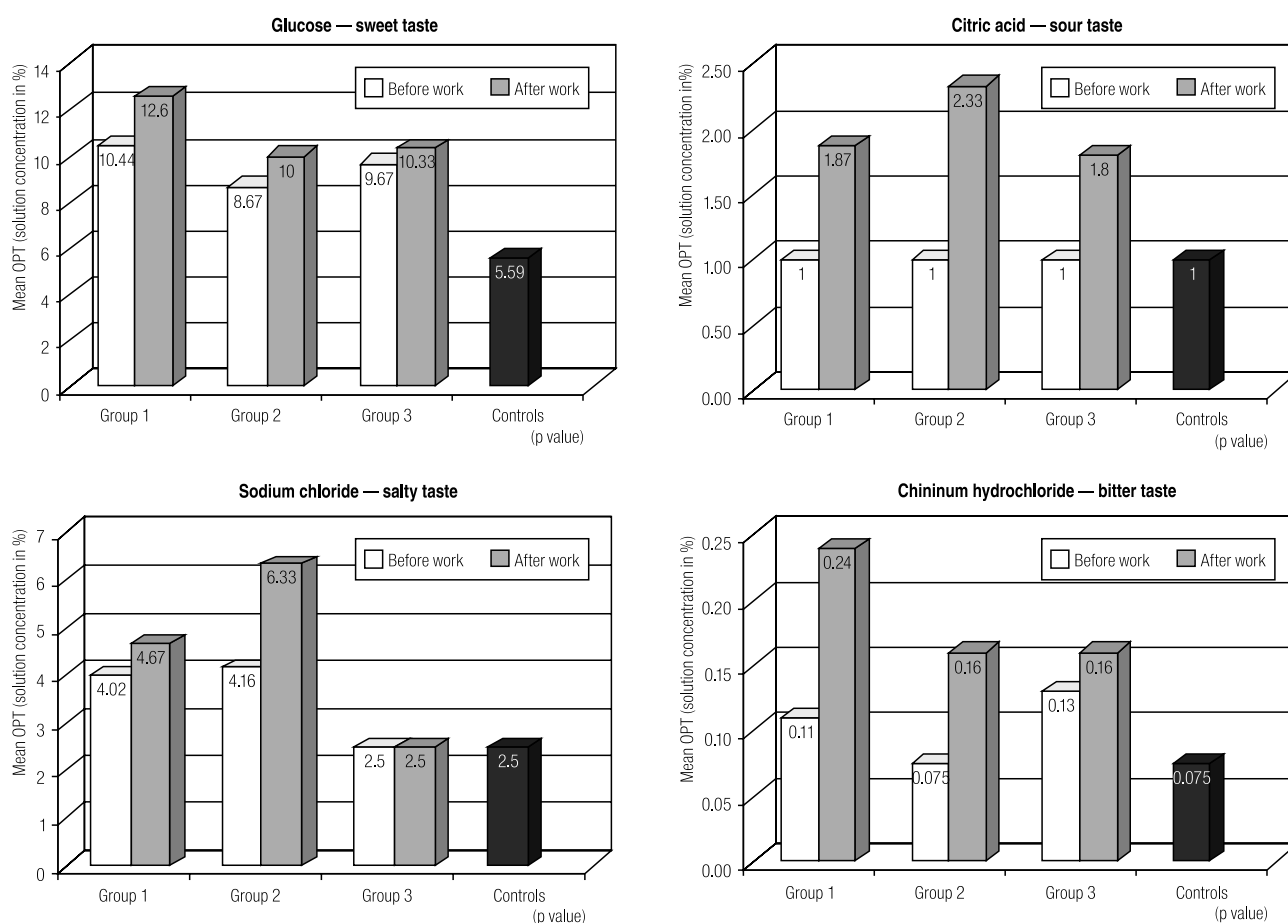
Olfactometry carried out after work shift revealed an increase in the mean OPT for each odour, but this change was not statistically significant and the findings did not differ substantially between the groups (Fig. 2).

## DISCUSSION

An increased interest in occupational diseases resulted in broad implementation of hygienic standards and safety solutions to protect the workers against exposure to toxic agents in work environment. Nonetheless, working at a sewage treatment plant or waste landfill is still connected with exposure to a variety of harmful physical, chemical and biological agents. Many authors reported on an

increased risk of irritation of the respiratory system, eyes, and skin as well as the neurological and gastric symptoms among sewage workers and landfill workers [18–19]. The upper respiratory tract with the olfactory and gustatory receptors is particularly exposed to the activity of hazardous agents. However, available literature lacks reports on the evaluation of the taste and smell senses in this profession. Therefore, the aim of the present study was to assess the functions of these senses among sewage treatment and waste landfill workers exposed to harmful agents in workplace.

The results of gustometric and olfactometric examinations performed before the onset of work were compared with those recorded for the control group to estimate the influence of chronic exposure on the sense organs. Gustometry conducted before work revealed that dysgeusia occurred



Group 1 — Sewage workers, Group 2 — Landfill workers, Group 3 — Laboratory workers.  
The mean OPT is the mean of all OPT measurements for each substance in a given group.

**Fig. 2.** Comparison of mean olfactory perception thresholds (OPT) before and after work in particular study groups.

in nearly 20% of workers, irrespective of their job. Abnormal perception threshold applied to the sweet, bitter and salty tastes. It was found that in each group, the sour taste was the only one that functioned correctly. Additionally, the olfactometric examination showed a significantly higher percentage of smell disorders in all the examined groups, compared to the control group. Olfactory disorders were noted mostly among sewage workers and landfill workers, 30% of whom suffered from hyposmia and anosmia. Both the workplaces are associated with exposure to agents that have a damaging effect on the smell receptors. The frequency of olfactory disorders among sewage workers was comparable to the frequency of nasal cavity irritation (26%) observed by Krajewski et al. [9] in the same profession. A higher percentage of smell disorders (45%) was noted for workers with long-term exposure to heavy

metals [20]. As it could be expected, the laboratory workers who had little contact with toxic agents, recognized smells better than did the sewage workers and landfill workers, but their results differed from those for the control group. The findings confirmed the suggestions of other authors with regard to an irreversible dysfunction of the smell and taste senses in workers under long-term exposure to harmful agents in workplace [21]. The examinations of the gustatory and olfactory thresholds after 8-hour workday made it possible to assess the changes in the sensory perception after short-term exposure to hazardous agents. We noted that the perception of taste deteriorated after work in each workplace, but the change in TPT was statistically significant only in the sewage workers and landfill workers. An interesting finding was the highest increase in TPT for the sour taste, whereas

it was the only taste that functioned correctly at the first examination. Therefore, it appears that the dysfunction of the sour taste perception is reversible and that the other tastes are more sensitive to the chronic activity of toxic agents. Changes in taste perception after 8-hour occupational exposure to toxic chemicals were reported also by other researchers [21]. It seems that a reversible, temporary dysfunction of smell and taste may be due to a fatigue of the sensory receptors which is observed even after short-term exposure to harmful agents in workplace.

Olfactometry performed after work showed an increased level of OPT in each group, but the change was not statistically significant. No differences in olfactometric measurements were found between particular workplaces.

In the analysis, we also considered other factors that could have influence on the results. A statistical analysis (testing for independent variables) was performed to check the influence of the differences in the subjects' age and employment duration (Table 2). The total duration of employment did not differ statistically between the groups.

**Table 2.** Statistical analysis of between-group differences in the subjects' age and duration of employment

Parameter	Employment duration (years)		t	P
Mean				
Group 1 vs. Group 2	15.167	9.417	1.493	0.148
Group 1 vs. Group 3	15.167	14.792	0.083	0.934
Group 2 vs. Group 3	9.417	14.792	-1.649	0.113
	Age (years)		t	p
Average				
Group 1 vs. Group 2	42.800	34.583	2.538	0.018
Group 1 vs. Group 3	42.800	44.167	-0.355	0.725
Group 2 vs. Group 3	34.583	44.167	-2.863	0.009

The statistical analysis revealed age differences between particular subgroups. Thus, we decided to compare the TPT and OPT measurements recorded before and after work in these groups with the findings for the control group.

Some authors postulated that the functions of both the senses deteriorated with age, but this was not confirmed in other reports. Some researchers suggest that an increase

in TPT and OPT levels occurs after the age of 60 years, but in our study the oldest worker was 55 years of age (in the control group there was one worker who was 62 years old). Therefore, the age difference did not have any significant impact on the study results.

The number of male and female subjects in the study groups (gender factor) is related to the specific character of each workplace. The males are more frequently employed in wastewater treatment plants and landfills while the females in laboratories. Therefore, it is very difficult to analyze the impact of the gender factor on the taste and smell perception in workers at these workplaces. In the present study, the TPT and OPT measurements were compared with those for the control group where the proportion of both genders was similar.

The analysis of the study results indicate an increased risk of the smell and taste dysfunctions in workers with a long duration of employment in a sewage treatment plant and/or waste landfill. For a detailed interpretation of the findings for TPT and OPT in the context of occupational exposure it would be necessary to carry out measurements of the concentrations of air pollutants in each workplace, which could be the subject of further studies.

There are literature reports on the studies concerning air concentrations of harmful biological and chemical agents in the sewage treatment plant and landfill areas [5,18,22–23]. Studies investigating the correlation between exposure to hydrogen sulphide and endotoxins and the illnesses diagnosed among sewage and landfill workers were conducted by Ray [23], Abdou [24] and Lee [19]. They noted a statistically higher rate of irritation of the respiratory system, eyes and skin as well as the neurological and gastric symptoms. This increased rate was found even at exposure to hydrogen sulphide below the level of 1 ppm, and endotoxins below 91 units per m<sup>3</sup> (EU/m<sup>3</sup>). Smit et al. [18] observed an increased frequency of health problems under conditions of endotoxin exposure above the level of 50 U/m<sup>3</sup>.

The technological development and progress in occupational medicine makes it possible to monitor and limit occupational exposure to chemical and biological hazards, thus diminishing their influence on workers' health [25]. The quantitative and qualitative tests of smell and taste

could serve as indicators that would help detect the hazards and enhance systematic monitoring of the functions of sense organs. Performing these tests on workers occupationally exposed to harmful agents provides an opportunity for assessment of the compensatory ability of both the sense organs [26].

Own experience in investigating the sensory dysfunctions prompts a complex nature of the causes of dysfunctions reported in the present study. Presumably, a dysfunction takes place at several stages of the reception of the sense stimulus. It is plausible that even the first stage i.e. reaching the receptor by stimulus, can be hindered by a mechanical barrier, namely oedema of the mucous membrane irritated by airborne particulates. The process of dissolving chemical stimulus in the mucus layer often becomes abnormal because of the changes in the mucus composition that result from occupational exposure. This leads to a decrease in the connection between the stimulus and the receptor. The functions of the gustatory and olfactory receptors, which are directly exposed to toxic agents, could also be considered. There is a hypothesis that the sensory neuroepithelium is sensitive to environmental exposure to pollutants [27–29]. Finally, the changes can also relate to further parts of the sensory tract.

The knowledge about the influence of long-term exposure to chemical hazards on the senses of smell and taste is inadequate. Occupational dysfunctions of the smell and taste are usually subclinical and can often be found only during the olfactometric and gustometric examinations. Therefore, the findings presented above show a need for a further research in this area.

## CONCLUSION

The gustometry and olfactometry results indicate a higher risk of smell and taste dysfunctions among sewage treatment and landfill workers. The sense of the sour taste appeared to be most sensitive after short-term exposure, but this dysfunction is probably reversible in nature. The other tastes were found to be more sensitive to chronic toxic exposure than the sour taste. Occupational dysfunction

of the senses is usually multicausal and subclinical in nature. It can often be found exclusively during professional examinations.

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