



Examining odor-producing chemical gases in Gohar-Rud River and their potential effect on residents surrounding: A case study

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ABSTRACT

In developing countries such as Iran, where comprehensive wastewater treatment measures have yet to be implemented, sewage disposal in rivers represents a means of eliminating it. This phenomenon results in the transformation of urban rivers into open sewers. The study's objective was to quantify the odor-producing gases and assess their potential impact on the residents in the vicinity of the Gohar-Rud River in Iran. The identification and measurement of odor-producing gases from this sewage river were conducted through the sampling and laboratory analysis of gases such as hydrogen sulfide, ammonia, and mercaptans in the initial area of human exploitation near the river. This was carried out following the global NIOSH method. The study was conducted by distributing questionnaires to residents near the river, and the results were subsequently analyzed using SPSS software. Based on field observations and laboratory studies on odor-producing gases, it can be concluded that hydrogen sulfide with an average concentration of 3.51 ± 0.09 ppm, is the primary cause of odor in this river. The findings of this study demonstrate the impact of the Gohar-Rud River's unpleasant odor on the health and quality of life of those residing in its vicinity. This was achieved through the utilization of self-perceived and self-sensory methodologies. The results show that the level of life convenience influences the quality of human life. In this regard, qualitative criteria such as convenience with health, good mental conditions, and having stable conditions in daily habits can be effective. The level of convenience with the quality of life in the marginal residents of Gohar-Rud River based on the level of enjoyment of life in daily activities is low. Inconvenience with health and nervous disorders is important in reducing the level of convenience among the residents of this river.

Keywords: Air pollution, Unpleasant odor, Rasht, Gohar-Rud, River.

Article type: Research Article.

INTRODUCTION

Odor pollution is one of the factors that typically has a detrimental impact on human quality of life as indicated by the World Health Organization (Ergün Yüksel *et al.* 2024). Unpleasant odors causing inconvenience in human societies make it essential to investigate the quality and quantity of odor-producing gases (Conti *et al.* 2020). The expansion of urbanization and the lack of sewage treatment inevitably result in sewage discharge into rivers. This is a significant issue in developing countries such as Iran. Discharging sewage into urban rivers with large volumes of organic matter creates anaerobic conditions, decomposes organic matter, and produces odor compounds (Mehravaran *et al.* 2017). Gases and compounds such as ammonia (NH₃), hydrogen sulfide (H₂S), and mercaptans can produce odor (Talaie Khozani 2018). Humans have different thresholds of odor (Oettl *et al.* 2018). In countries such as Austria and Germany, exposure is more than 6 minutes to evaluate the presence of one odor unit per cubic meter (m³). In other European countries, the average exposure per hour is used (Weitensfelder *et al.* 2019). The

molecules of these substances elicit the sensation of smell by stimulating the olfactory receptors, which are sensitive cells located in the olfactory organs (Shokri 2019). The ability to perceive odors varies considerably from one individual to another. Furthermore, a person's tolerance to odor depends on the time of exposure, the intensity of the odor, and the specific characteristics of the odor in question (Sado-Inamura & Fukushi 2018). Additionally, these substances have been demonstrated to affect various organs in the body (Antonopoulou *et al.* 2014), thereby placing human health at risk (Team of Microbiology Assistants 2016). The odors are evaluated by individuals in the community exposed to these gases (Sakawi *et al.* 2011) and generally have a negative perception (Demircan 2018). People exposed to malodorous compounds, describe them as unpleasant odors (Aatamila *et al.* 2020). Negative odor perceptions lead to public complaints (Weitensfelder *et al.* 2019). One of the main components of research on the impact of bad smells on societies is the employment of survey questionnaires, based on which a single assessment can be achieved (Johnson *et al.* 2007). Overall, odors can affect not only the routine of people's daily life (Shanahan *et al.* 2014), but also their decisions (Sharida *et al.* 2019), their health, the health of human societies, and the quality of work (Byliński *et al.* 2019). It has been documented that in regions where odor pollution is prevalent, certain daily activities are perceived as less desirable, including holding windows open, staying on balconies or gardens, and engaging in outdoor pursuits such as walking, running, and cycling (Ergün Yüksel *et al.* 2024). Previous studies on the unpleasant odors of animal stables in Arizona State, USA, indicated that workers' sleep is disturbed (Ulutas *et al.* 2017). The effects of unpleasant odors in Quito, Ecuador using a self-report questionnaire, indicated a decrease in happiness and life satisfaction in people exposed to unpleasant odors (Herra *et al.* 2022). Gohar-Rud River is located in one of the most important, busy, and tourist-friendly provincial centers in Northern Iran. It flows in an area with high groundwater levels. Its course as a sewage river, in addition to affecting groundwater resources, impacts the lives of river residents, passing citizens, and tourists in this area. It flows into Anzali Wetland at its destination after passing over 40 km long (Tavakoli 2019). This river is a south-north water flow that affects a large part of Rasht City, which is 16 km long. This study aimed to identify and quantify odor-producing gases in this river. Also, we aimed to determine the potential effects of unpleasant odors on the people who live or work near the river. The results of the investigation of the odorous gases in this river and the level of satisfaction of the residents around it can lead to a better understanding of the environmental conditions and attention to environmental management.

MATERIALS AND METHODS

This descriptive study was conducted in Rasht City, Northern Iran in 2019. In the first step, a preliminary survey was conducted in the study areas along the Gohar-Rud River to identify and measure the odor-producing gases. So, odor-producing gases including hydrogen sulfide, ammonia, and mercaptans (Antonopoulou *et al.* 2014) were investigated to identify the initial human exploitation in the marginal parks of the Gohar-Rud River. The playground equipment in the park and special walks for city dwellers were evaluated using the global NIOSH method at a height of one meter from the ground. At first, ten stations situated at a distance of less than 100 meters from the river were selected during the summer months with the objective of including both busy locations and tourist attractions within the marginal parks. To study the hydrogen sulfide, we connected the filter + solid sorbent tube (Zefluor, 0.5µm; coconut shell: charcoal, 400 mg/200 mg) to the personal sampling pump (SKC company - England, the standard model) with 0.2 L min⁻¹ discharge rate adjustment for 60 minutes for each sampling. The samples were taken with three replications in each of the 10 stations. The experimental analyses were performed by ion chromatography technique Metrohm ion chromatograph, Switzerland, model 881 Compact IC pro), equipped with Metrosep A Supp 10-250 anion column and C 4-250/4.0 Metrosep cation column, MagIC Net 2.3 software (NMAM 6013). To study the hydrogen sulfide by connecting the filter + solid sorbent tube (Zefluor, 0.5µm; coconut shell: charcoal, 400-- mg/200- -mg) to the personal sampling pump (SKC company - England, the standard model) with 0.2- L min⁻¹ discharge rate adjustment for 60 minutes for each sampling. The samples were taken with three replications in each of the 10 stations. The experimental analyses were performed by ion chromatography technique) Metrohm ion chromatograph, Switzerland, model 881 Compact IC pro), equipped with Metrosep A Supp 10-250 anion column and C 4-250/4.0 Metrosep cation column, MagIC Net 2.3 software (NMAM 6013). Two sampling methods were employed to obtain air samples from the area surrounding the river to investigate the presence of mercaptans in the environment. First, a Mercapetan No. 70 tube detector (Gastec Pump model GV-100 JAPAN) with 100 mL suction capability was used to perform a series of 10 suctions at each sampling point with time intervals of 1.5 min between suctions. In the second method, the fiberglass filter was

impregnated with mercury acetate and connected to the personal sampling pump (SKC company - England, standard model) with an adjusted discharge rate of 0.2 L min^{-1} for 180 min in each sampling, with three repetitions in each of the 10 stations, resulting in the preparation of samples.

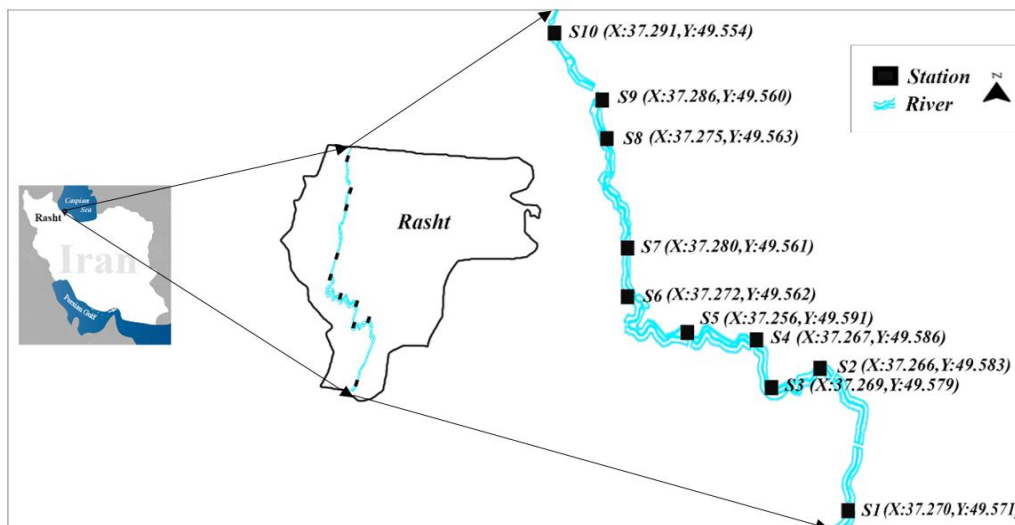


Fig. 1. Geographical coordinates of sampling stations in Gohar-Rud River.

The samples were subjected to analysis using a GC-MS instrument (Agilent 1890, USA) equipped with a quadruple mass selective detector (mass spectrometer; NMAM 2542). To test the ammonia, samples were taken by attaching a solid sorbent tube filled with silica gel and impregnated with sulfuric acid to a personal sampling pump (SKC England, the standard model) with the discharge rate adjusted to a flow rate of 0.2 L min^{-1} was maintained for 60 minutes at each of the 10 sampling stations, with three repetitions conducted at each station. The determination was performed using a spectrophotometer (METROHM, Switzerland) in the visible wavelength range (NMAM 6015). This study aimed to investigate the potential impact of unpleasant odors on the health and quality of life of marginal residents in the Gohar-Rud River area. So, a self-perceived method was employed, utilizing questionnaires to collect data. The statistical population was determined to be 380 individuals according to the marginal population (42105 persons), using Cochran's formula. To ensure confidence in the results, a 10% increase in Cochran's inferential statistics was applied, resulting in a sample size of 420 individuals. These individuals were selected using a random sampling method, and the results were analyzed using IBM SPSS software (Version 23).

RESULTS AND DISCUSSION

The findings of this study can be divided into two sections. Following an examination of the odor-producing gases on the banks of the Gohar-Rud River, experimental studies indicated that hydrogen sulfide is the primary factor contributing to the river's odor. The results of 30 samples collected from 10 stations on sunny days with an average temperature of $30 \pm 1 \text{ }^\circ\text{C}$, in three repetitions for each station, are presented in Table 1 and Fig. 2 with an average concentration of 3.51 ppm and a standard deviation of 0.09. The detection limit was $< 0.06 \text{ ppm}$. The number of sewage outlets along the riverine environment varies from one to four outlets. According to the results, the highest hydrogen sulfide concentration was observed at Station 5, with a value of 4.23 ppm. This station exhibited the highest density of urban sewage outlets. Conversely, the lowest hydrogen sulfide concentration was recorded at Station 8, which possesses a single sewage outlet. The river near Station 8 flows on a sloping surface, which may facilitate air entry and disruption of anaerobic conditions. This, in turn, may lead to a reduction in hydrogen sulfide production. In the case of the mercaptan in the air around the Gohar-Rud River, the sampling and analysis were performed at 10 sampling stations using a mercaptan detector tube for 15 minutes at each sampling, with a detection limit of 0.3 ppm. We did not find any mercaptan at the ten stations. Therefore, sampling was conducted using three repetitions at each station following NIOSH2542 (GC-MS analysis) to ensure greater accuracy in determining the presence or absence of this gas. This approach revealed the absence of any peak associated with mercaptan in all chromatograms. Thus, the research yielded no evidence of mercaptan (Fig. 3). In the case of

ammonia, the sampling was repeated three times in each of the examined stations, with 30 samples taken from the air in all stations following NIOSH METHOD 6015 with a detection limit of 0.06 ppm, indicating the absence of ammonia in the area surrounding the Gohar-Rud River (Fig. 3). Attention must be paid to air pollution, as it is a significant determinant of human health (Wojnarowska *et al.* 2020).

Table 1. Hydrogen sulfide concentration on the banks of the Gohar-Rud River.

Station	H ₂ S concentration (ppm)		
	Sample 1	Sample 2	Sample 3
1	3.91	4.04	3.91
2	3.91	3.78	3.91
3	3.84	3.91	3.91
4	3.19	3.32	3.19
5	4.11	4.30	4.30
6	3.45	3.65	3.45
7	3.98	3.84	3.84
8	1.76	1.50	1.50
9	2.93	2.74	2.74
10	4.37	4.11	4.11

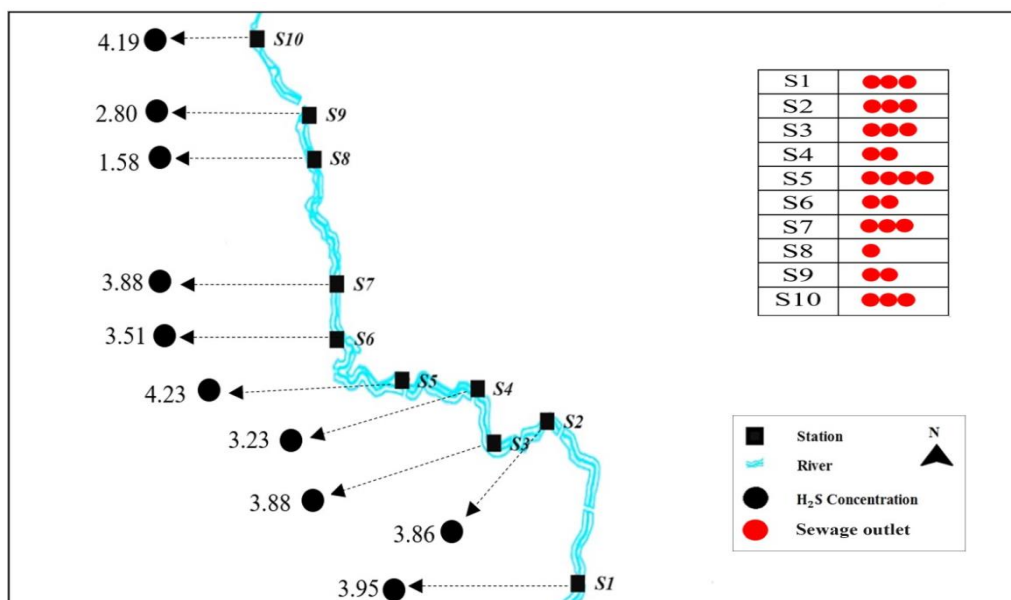


Fig. 2. Average hydrogen sulfide concentration (ppm) on the banks of the Gohar-Rud River.

The findings on this river indicate that H₂S is the primary odor-producing gas. The mean hydrogen sulfide concentration in densely populated areas was 3.51 ± 0.09 ppm. Demographic information in the studied area (Table 2) shows that 68% of the respondents were female and 32% were male. From the responses received, 0.5% related to the age range of under 15 years, followed by 20.2% in the range of 16 and 30 years, 47.6% between 31 and 45 years, 17.9% between 46 and 60 years, 12.1% between 61 and 75 years and 1.7% over 75 years old. Regarding the education variable, 2.1% were at the basic education level, 18.7% had graduated from high school, 59.2% were studying or had completed their higher education, and 20% had completed postgraduate studies. In total, 72% of respondents were married and 28% were single. The results of the self-perceived health status of residents near the Gohar-Rud River indicate a range of changes in the health of individuals, from rarely to always (Fig. 4). The evidence showed that 87.6% of interviewees experienced shortness of breath, 89.8% heart palpitations, 90% suffered from fatigue, 79.8% reported allergic reactions in the skin, and 72.6% experienced debilitating physical pain. The evidence suggests that an unpleasant odor can hurt health; however, the precise mechanism and detail remain unknown (Bluyssen *et al.* 2017; Moya *et al.* 2019). Research on the residents of residential complexes in the vicinity of the sewage treatment plant in Varberg, Sweden, indicated the presence of mental disorders among the residents (Byliński *et al.* 2019). Previous studies have demonstrated the occurrence

of anxiety in communities exposed to the unpleasant odor of chemical industries among employees in Bangalore, India (Weitensfelder *et al.* 2019).

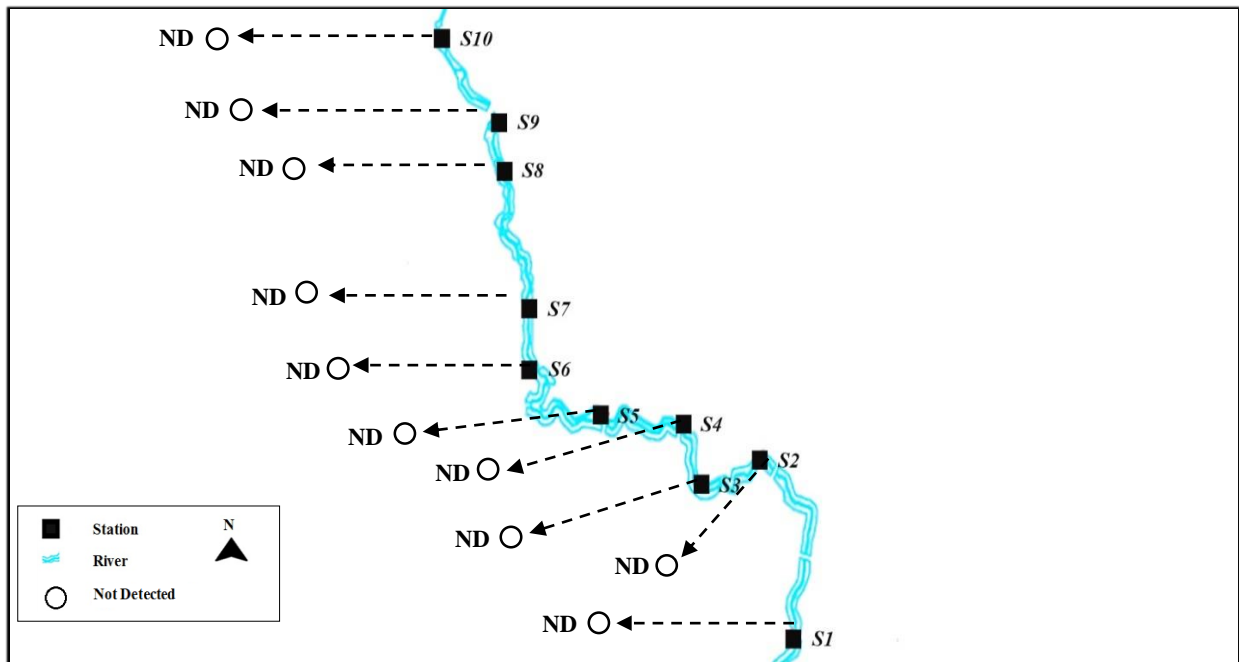


Fig. 3. Concentration of ammonia and mercaptans on the banks of the Gohar-Rud River.

Table 2. Demographic variables of the respondents.

Variable	Category	Rate (%)
Sex	Male	32
	Female	68
Age	<15	0.5
	16-30	20.2
	31-45	47.6
	46-60	17.9
	61-75	12.1
	>75	1.7
Education	Basic	2.1
	High school	18.7
	Higher education	59.2
	Postgraduate studies	20
Marital status	Single	28
	Married	72

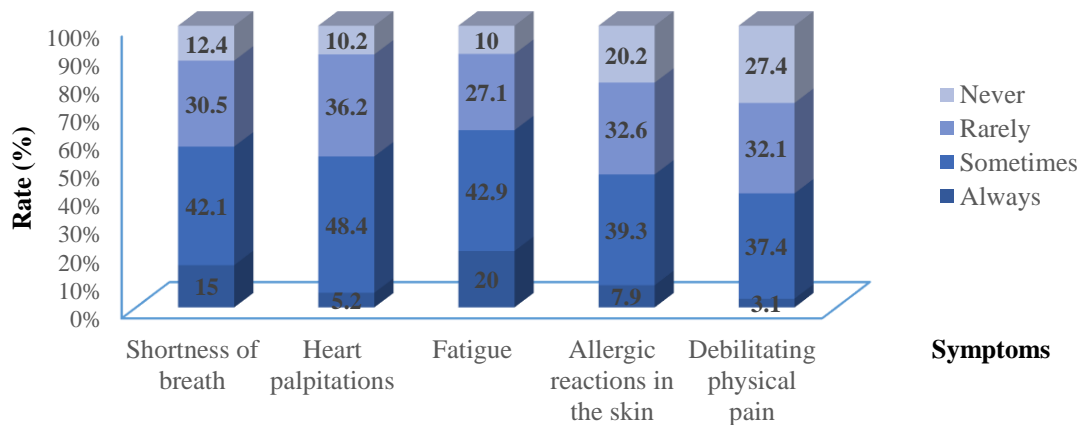


Fig. 4. Self-perceived dissatisfaction with health in the residents of the Gohar-Rud River.

The results regarding self-perceived nervousness among residents of the Gohar-Rud River indicate a range of experiences, varying from rarely to always (Table 4). In this study, 95.7% of interviewees reported experiencing nervous disorders, and 56.2% encountered disputes.

Table 4. Self-perceived nervous disorders among communities exposed to the unpleasant odors of the Gohar-Rud River.

Variable	Category	Rate (%)
Nervous disorders	Never	4.3
	Rarely	41.2
	Some times	37.4
	Always	17.1
Dispute	Never	43.8
	Rarely	15.7
	Some times	31.2
	Always	9.3

Individuals exhibited disparate behavioral responses to olfactory stimuli. It is more common for individuals to show these changes when subjected to prolonged and persistent olfactory stimulation (Johnson & Sobel 2017). Prior research reported that olfactory perception is associated with social dissatisfaction (Brancher *et al.* 2017). Unpleasant odors negatively impact the quality of life and have resulted in individuals leaving their residences. An increase in public complaints regarding unpleasant odors in the environment has been linked to a decline in remorse for relocation (Żróbek *et al.* 2015). The absence of unpleasant odors in the environment has been identified as a critical factor influencing residential property selection (Kempa *et al.* 2015). Furthermore, unpleasant odors, which may lead to economic devaluation, have been associated with economic damages (Demircan 2018). The findings presented in Table 5 indicate that the majority of marginal residents were inconvenienced by the presence of unpleasant odors during the warm seasons of the year. An analysis of the self-sensory experiences of the target community revealed that the highest level of inconvenience occurred in August. The results of the surveys on the level of convenience with the quality of life based on the enjoyment of daily activities in the riverside residents indicated that 6.7% of individuals were inconvenienced. The highest statistical rate, 78.8%, was related to individuals who experienced low convenience. Only 0.5% of individuals near the River area were very convenient, and 14% were convenient. The results obtained from the level of convenience with the quality of life are consistent with the previous evidence regarding the level of social inconvenience caused by the perception of smell.

Table 5. Self-perceived satisfaction with the quality of life among communities exposed to the unpleasant odors of the Gohar-Rud River.

Variable	Category	Rate (%)
Unpleasant odors	Never	0
	Rarely	36.2
	Some times	61.4
	Always	2.4
Satisfaction with quality of life	Inconvenient	6.7
	Having low convenient	78.8
	Being convenient	14
	Being very convenient	0.5

CONCLUSION

This research presents the results of the unpleasant odor in the Gohar-Rud River in quantitative and qualitative forms. A comparative analysis of the results of sampling and laboratory examinations with environmental conditions indicated that in the stretch of the river where the slope is low, the flow of water is slower and the number of outlets discharging into the river is greater, the concentration of H₂S is higher, resulting in a more pronounced odor. Furthermore, the inhalation of unpleasant odors is associated with sampling on days when there has been a sustained increase in ambient temperatures over the preceding days, accompanied by elevated humidity due to the absence of precipitation and wind. The findings of this study demonstrate the impact of the odor emanating from the Gohar-Rud River on the health and quality of life of those residing in its vicinity. This was achieved through the use of self-perceived and self-sensory methodologies. The results show that an individual's quality of human life is influenced by their level of life convenience. Qualitative criteria such as convenience with

health, positive mental well-being, and stable daily habits can effectively indicate an individual's quality of life. The level of convenience and quality of life among the marginal residents of the Gohar-Rud River is low, based on the enjoyment of life in daily activities. Factors such as inconvenience with health and nervous disorders play a significant role in reducing the level of convenience among residents of this river. Given the expressed desire of 100% of residents near the river with higher education and postgraduate studies to publish the findings of this study, it is hoped that the publication of the results will lead to an elevation in demands from the general public, thus providing a practical step in the planning of local managers and attracting investment at the regional and national levels. The quantitative and qualitative analyses of the unpleasant odor of this sewage river have prompted the relevant managers to implement control measures, reduce the problem, and address it as a priority in urban management.

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CONFLICTS OF INTEREST

The authors declare that they have no conflict of interest.

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