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Regulation of salinity to inhibit 2-methylisoborneol and geosmin: Insights from spatial-scale research in coastal areas of China

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Drinking water quality and the commercial value of aquatic items are both significantly impacted by odor molecules like 2-methylisoborneol (2-MIB) and geosmin (GSM). Many investigations have been conducted to identify the microorganisms involved in the synthesis of 2-MIB and GSM. However, few studies have attempted to identify potential degradation factors in the natural environment. Here, pathway analysis of the relationship between water quality parameters and the distribution of odor compounds in water bodies led to a more significant connection ($p < 0.05$) between total nitrogen, total phosphorus, chemical oxygen demand, and salinity in water bodies for the distribution of their odor compounds. Salinity among them exhibited the strongest connection and had a direct impact. The establishment of a larger spatial scale statistical research method, mainly using the water environment with different salinities formed in different geographical areas, and the distribution of odor compounds in this water body as a research vehicle helped to find the most concise relationship between the two variables. The results show that the concentration of odor compounds is lower in waters with higher salinity, which proves the negative correlation between the two. The results of this study provide a theoretical basis for solving the problem of odorous pollutants in water bodies, with the aim of improving the utilization of water resources more effectively and, secondly, leading to a new guiding direction for the conservation and exploitation of impact plains and mudflats.

KEYWORDS

2-methylisoborneol, geosmin, water quality parameters, pathway analysis, coastal mudflat, natural inhibitor

1 Introduction

A healthy, odor-free water environment is what people expect, but with rapid socio-economic development, increased human activity, and the discharge of pollutants, the problem of water pollution often arises (Ajibade et al., 2021). The presence of odorous substances in water bodies is still a major concern. The production of odorous substances in water bodies is often accompanied by eutrophication of the water body and is generally produced by the metabolism of algae and bacteria, mainly 2-methylisoborneol (2-MIB) and geosmin (GSM). As they are trace amounts of volatile organic pollutants, they have a very low olfactory threshold concentration of 10 ng/L and can be detected by human olfaction (Young et al., 1996), posing a threat to water quality and public health (Zhang et al., 2009; Fu et al., 2021). Odor substances in water not only have an impact on the health of drinking water, but also on the survival, development, and reproduction of aquatic organisms, for example, 2-MIB has an impact on the development of embryos and offspring of fish such as *Danio rerio* (Zhou et al., 2021).

Currently, many studies have focused on the identification of microorganisms involved in the generation of odor compounds, as well as on the techniques for the removal of odor compounds already present in water, and it is more generally accepted that algae and bacteria in the water column are the direct and main cause of odor compound production (Son et al., 2015). Secondly, some studies have also conducted correlation analysis on water quality factors on the distribution of odor compounds in water bodies, but the effects of these water quality factors on the distribution of odor compounds in different study water bodies are uncertain, which show both positive and negative effects (Shu-Chu et al., 2008; Tung et al., 2008; Ding et al., 2014; Zhen et al., 2014; Hu et al., 2017), which arises from the complexity and uncertainty in the production and volatilization of odor compounds in water bodies. There are also a significant number of findings showing a negative correlation between salinity and the concentration of odor compounds in this water body (Tosi and Sola, 1993; Nam-Koong et al., 2016), which is an interesting phenomenon, but the mechanistic principles involved are not clear. The production of odor compounds in water bodies mainly originates from algae and bacteria, and the concentration distribution in the aqueous environment is subject to a combination of pathways including production and disappearance. The production is mainly through the metabolic production of algae and bacteria, while the disappearance is mainly through dissipation and volatilization, etc. Current research has shown that water quality factors have a certain correlation between algae and bacteria (Naughton et al., 2020), which will undoubtedly indirectly affect the distribution of odor compounds in the water column. However, it is not reported whether water quality factors have a facilitative or mitigating effect on the storage of odor compounds in water bodies, i.e., whether there is a direct relationship between them is unclear.

China is a vast country with huge differences in climate, topography, population density, and economic development levels, and its watershed environment may show different states in different regions. For example, in the coastal areas of southeast China, the waters are densely distributed; however, in northwest China, there are mostly arid and semi-arid areas. Water resources are also more abundant in southern China than in northern China. Different water environments and geographical differences also cause differences in water quality factors, which also include salinity. The variation of salinity distribution is an important factor that influences and restricts the distribution and variation of other hydrological factors (Bai et al., 2012). For example, the salinity at the mouth of the Yangtze River Delta and Pearl River Delta is significantly higher than that of other waters and shows a pattern of higher salinity the closer to the coastline (Chen et al., 2008; Xie et al., 2021). Precipitation is also an important factor affecting the salinity of regional waters. Northern China is dominated by a temperate continental climate and temperate monsoon climate, with low precipitation throughout the year, while southern regions have abundant precipitation (Zhou and Yu, 2005). This geographical difference in water quality may affect the distribution of odor-producing algae and bacteria in water, but it is unknown whether odor compounds in their water bodies are directly affected and the mechanism of the effect.

Coastal mudflats, located in the transition zone between terrestrial and marine ecosystems, are one of the important environmental resources, while the abundant vegetation on tidal flats accumulates a large amount of organic carbon, which is important for global climate change, sea level rise, and fall, and material cycling (e.g., water, sand and nutrient transport, carbon, nitrogen, and phosphorus cycling and fate, etc.). Especially with a series of high-intensity developments such as rapid urbanization in China's coastal areas, there will also be some impacts on their water environment (Selkoe et al., 2008). The coastal mudflat area of Jiangsu is one of the few typical pristine coasts in China and the world, which has largely maintained its natural ecological structure and function (Chi et al., 2011; Xu et al., 2011; Wang et al., 2020). In addition, as the largest silty tidal flats in China, the tidal flats are well developed and have obvious zonation due to the large tidal difference and strong tidal action along its coast (Zone et al., 2005). We investigated the correlation between water quality factors and the presence and distribution of odor compounds in the mudflats of Jiangsu coastal mudflats, and combined the results of the survey data to further investigate the possible effects of mudflat formation processes and geospatial differences on the odor compounds in the water bodies. In this paper, the innovative research objective is to identify the potential degradation factors of odor compounds in the natural environment, which provides a research basis for solving the problem of odor pollutants in water bodies, to improve the utilization of water resources more effectively, and secondly, to lead a new guiding direction for the conservation and development of impact plains and mudflats.

2 Materials and methods

2.1 Sampling deployment and water sample collection

A strategy was developed to select sampling points in the tidal flat area of Jiangsu province, China, based on distance from the coastline (represented in Figure 1). 252 samples were collected from 84 sites, with water samples collected from three uniform points at each site. The samples were extracted from a depth of 0.5 m, mixed

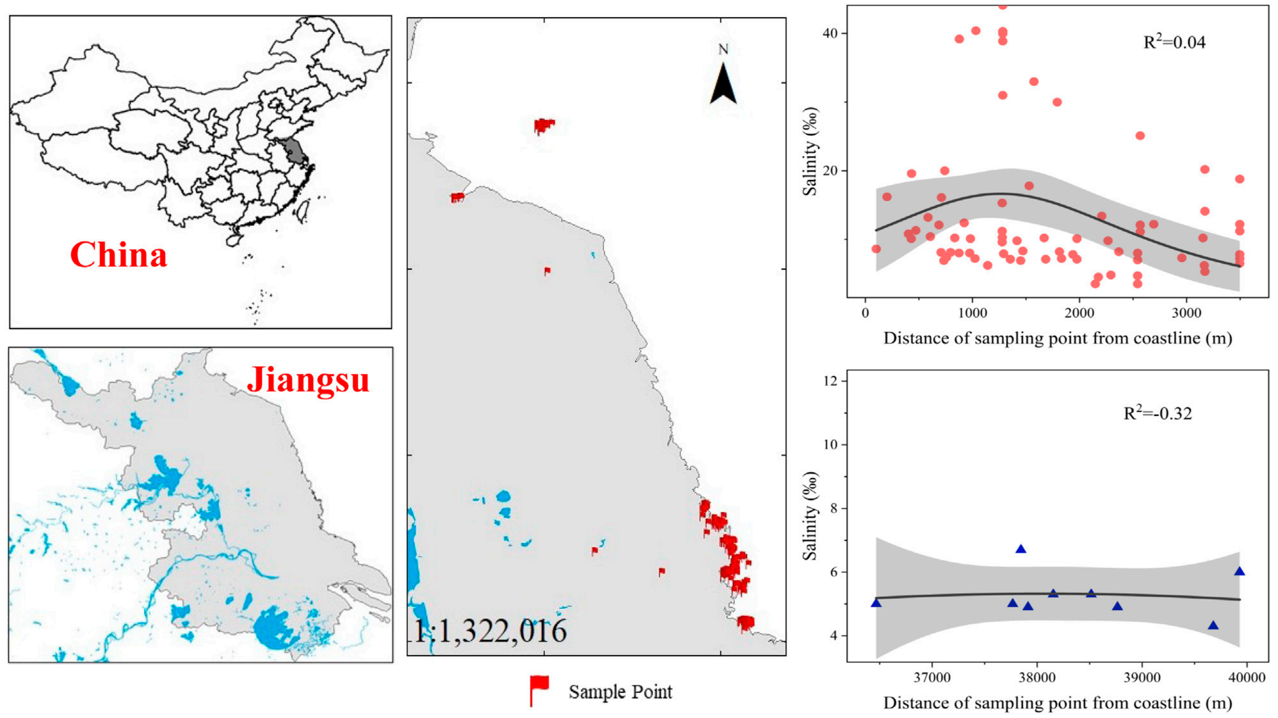

FIGURE 1
Distribution of sampling points in the tidal flat area (Jiangsu province, China) and its distance from coastline.

into one sample for analysis, and stored in amber glass bottles and refrigerated to 4°C. Most samples were tested within 72 h.

2.2 Determination of 2-MIB and GSM concentrations

The headspace solid phase microextraction (HSPME) method with gas chromatography-mass spectrometry (GC-MS) was used for the detection of odorants in the water samples.

We used HSPME to extract 2-MIB and GSM from water samples by sorption. We measured 10.0 mL of water sample (natural water should be filtered by 0.45 μm membrane) in a 20 mL headspace vial, added 10 μL of internal standard spiking solution (IBMP, mass concentration of 10 μg/L), i.e., the mass concentration of IBMP in water was 10 ng/L, then added 2 g of NaCl, immediately capped the vial and gently shaken well, and put it in a 70 °C water bath after the NaCl was completely dissolved. The extracted fibers were heated and pressed down to the top space for sorptive extraction. After the extraction for 30 min, the extracted fiber was removed, the sorbent needle was dried, and the extracted fiber was inserted into the gas chromatography injection port and desorbed at the injection port temperature of 250 °C for 5 min and chromatographed by mass spectrometry.

Gas chromatography-mass spectrometry (GC-MS) was used for the detection of 2-MIB and GSM concentrations in water samples. A DB-5 column (30 m × 0.25 mm×0.25 μm) was selected as the separation part of the chromatography, and the starting temperature of the column chamber was set to 50 °C and held for 1 minute, ramped up to 120 °C at a rate of 10 °C per minute and held for 1 min, and ramped up to 220 °C at a rate of 20 °C per minute and held for 1 min. In the specific chromatographic conditions, we set the injection mode as non-split, the inlet temperature as 250 °C, the inlet pressure as 7.66 psi, the total flow rate as 44 mL/min, and the carrier gas as helium high-purity (purity >99.999%) with a flow rate of 1.0 mL/min to achieve better chromatographic results. In the mass spectrometry, an electron ionization source (EI) was selected as the ion source with ionization energy of 70 eV, ion source temperature of 230 °C; MS quadrupole temperature of 150 °C; transmission line temperature of 250 °C; solvent delay of 5 min; and scan mode of ion detection (SIM) (Supplementary Table S1).

The detection limit of both odorants was 0.5 ng/L, with recoveries ranging from 91.2% to 112.5% for 2-MIB and 88.4%–109.7% for GSM, based on a signal-to-noise ratio of 10.

2.3 Seven basic water quality factors and salinity determination methods

The study measured water quality indicators such as salinity (SA), pH, dissolved oxygen (DO), temperature (T), chemical oxygen demand (COD), total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS). These were measured using handheld refractometers, pH meter, dissolved oxygen meter, and national standards of the People's Republic of China. The results for TN, TP, COD, ammonia nitrogen, and suspended matter were determined using neutral reagent photometric and gravimetric methods, while the national standards for potassium persulfate oxidation and ammonium molybdate spectrophotometry were also used (GB11894-89).

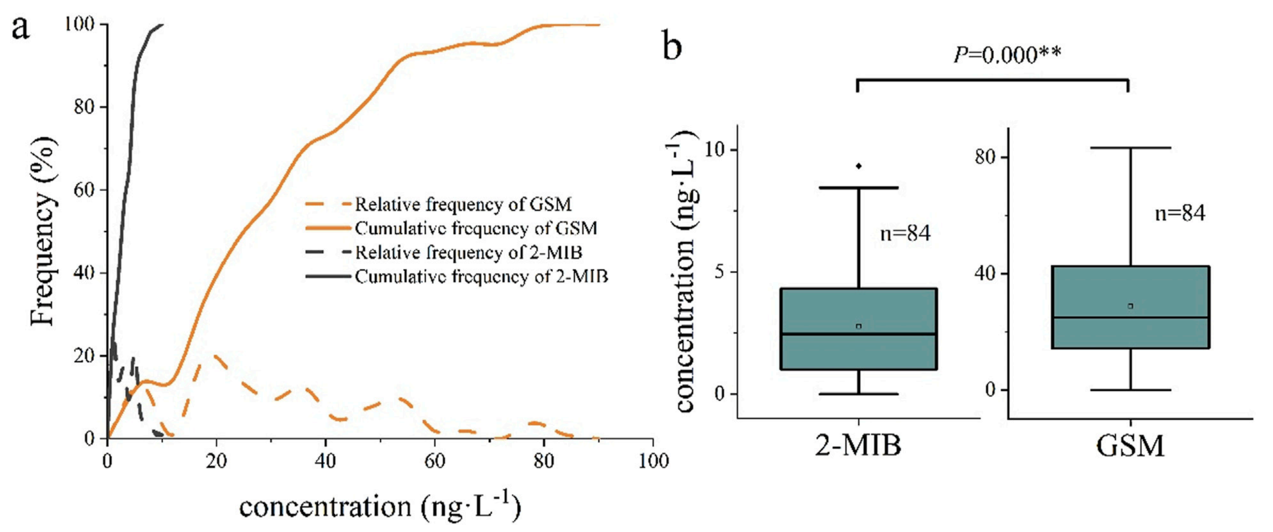

FIGURE 2
Concentration distribution of odorous substances. **(A)** Distribution of the concentration of odorous substances (2-MIB and GSM) in the water at sampling points in the tidal flat area. **(B)** The concentration of odorous substances (2-MIB and GSM) in water at sampling points in tidal flat area, "n" represents the number of sampling points, "**" means the difference is very significant ($P < 0.01$).

2.4 Path analysis

Path analysis is a technical approach to distinguish between causal models and is used to establish hypothetical pathways that explain the relative importance of environmental water quality factors on changes in odor compound concentrations (Luo et al., 2020; Shao et al., 2022). Before modeling, a K-S (Kolmogorov-Smirnov) test was performed on odor compound concentrations and water quality factors to determine whether the data conformed to a normal distribution. This study included six main water quality impact factors, namely, salinity, pH, dissolved oxygen, temperature, chemical oxygen demand, total nitrogen, total phosphorus, and suspended solids. These factors interact with each other and determine the changes in the concentration of odor compounds to varying degrees through direct or indirect effects. For example, TN and TP play an important role in the production of odor compounds by influencing the distribution of odor-producing algae and bacteria in the water column, especially during the hot summer season. In this study, it was first assumed that all environmental factors have a direct effect on the levels of 2-MIB and GSM in the water column, which can be explained by the standardized path coefficient (β). β represents the relative contribution of each environmental factor, and the positive and negative values of the coefficients represent positive and negative effects, respectively, and the higher the absolute value of the coefficient, the more important it is for the distribution of odor compounds. Secondly, it is assumed that water quality factors also exist to indirectly influence the content of odor compounds in water. Based on the above assumptions, a path analysis model was established, and the model was debugged through regression analysis by gradually adding or removing paths. During the debugging process, the significance of each path test parameter needed to be determined, and when $p < 0.05$, the model was accepted and the optimal results of the model were determined, and the relative importance of different water quality factors on controlling the changes in the distribution of 2-MIB and GSM and the complex interactions between these factors were obtained.

3 Results and discussion

3.1 Distribution and influencing factors of odorous substances in water in coastal tidal flats area

Currently, 2-MIB and GSM are the two most dominant odor-producing compounds in water (Ma et al., 2018; Rongfang et al., 2018; Yuan et al., 2018). In this study, we collected water samples and examined 2-MIB and GSM in water bodies from coastal mudflat areas in Jiangsu province. The results are shown in Figure 2. The concentrations of 2-MIB and GSM in 84 water samples from this region were 2.60 ± 2.30 ng/L and 27.83 ± 20.07 ng/L, respectively, with GSM concentrations significantly higher than 2-MIB concentrations ($p < 0.001$). The formation of this difference in distribution may be related to the type and amount of algae and bacteria in the water column, and the proof of the main producers of these two odor compounds has been given successively by researchers, with 2-MIB mainly originating from actinomycetes and cyanobacteria in the substrate, and GSM mainly originating from *Streptomyces*, which is also one of its producers (Sugiura et al., 1998; Sugiura and Nakano, 2000). And, likely, the producers of odor compounds in the water bodies of the region are mainly bacteria.

3.2 Analysis of concentration relationship between main water quality factors and 2-MIB and GSM

Water bodies are a complex environment, but the conventional test indicators in water have been able to reflect the quality of a water

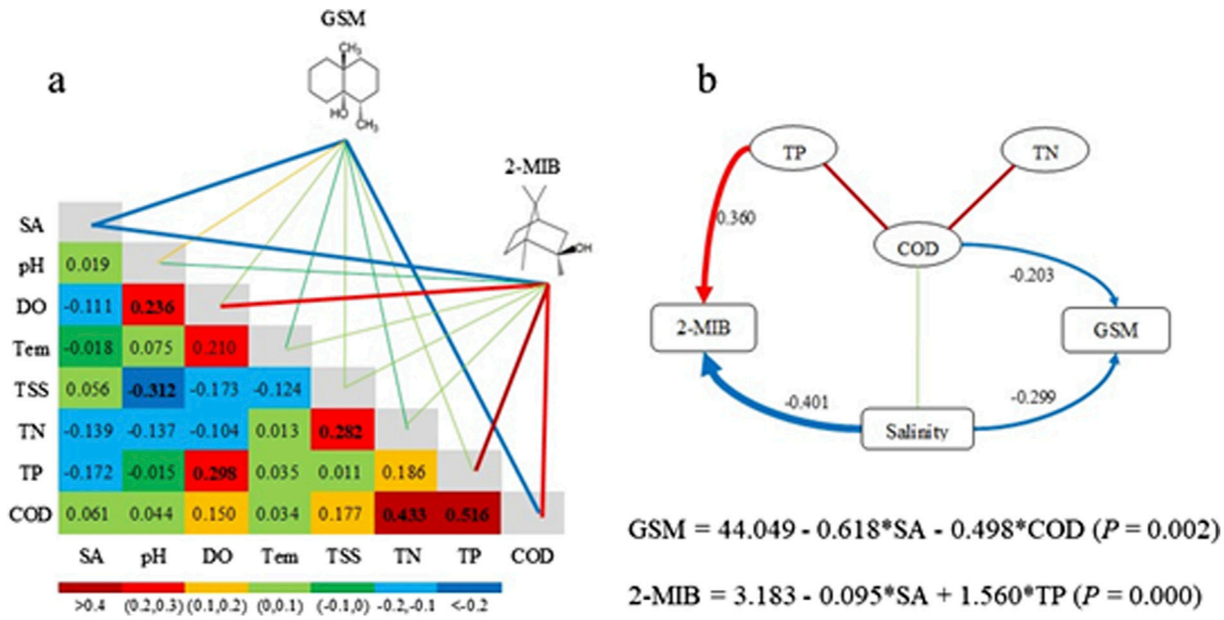

FIGURE 3
Relationship between environmental factors of water quality and two kinds of odor substances. **(A)** The relationship between the two odor substances (2-MIB and GSM) in the water samples in the beach area and the basic water quality factors. The larger correlation coefficient is shown as the darker color, and the red and blue respectively represent the positive and negative effects. **(B)** Size analysis describes two odor material and the main environmental factors, the relationship between the larger path coefficient is shown as broad arrow, positive and negative influences in red and blue, respectively. The formulas are multiple linear equations.

body relatively well, such as total nitrogen (TN), total phosphorus (TP), dissolved oxygen (DO), pH, temperature (T), chemical oxygen demand (COD), total suspended solids (TSS), and salinity (SA), and there are also interactions between the various water quality factors in a water body (Muhid et al., 2013; Vandergucht et al., 2013). In this study (Figure 3), there is a strong positive correlation between TN, TP, and COD with correlation coefficients of 0.433 and 0.516, respectively, since COD is a comprehensive indicator of water quality in response to water bodies. Few studies have focused on the effects of water quality factors on the concentration and distribution of odor compounds and their mechanistic mechanisms. Since it is not possible to identify the direct or indirect influence of water quality factors on the distribution of odor compounds, the choice of using statistical methods of through-way analysis is a reasonable approach (Park et al., 2021). We quantified the degree of influence of multiple influencing factors on the distribution of odor compounds in water bodies using path analysis, which decomposes the correlation coefficients of each independent variable with the dependent variable into the direct effect of the respective variable on the dependent variable and the indirect effect on that dependent variable through other independent variables, and therefore, the via analysis was used to examine the complex relationship between water quality factors and odor compounds (Fei-Yun et al., 2014). Herein, the screening results by path analysis showed (Supplementary Table S2; Supplementary Table S3) that 2-MIB concentrations were positively correlated with TP concentrations, while GSM concentrations were more influenced

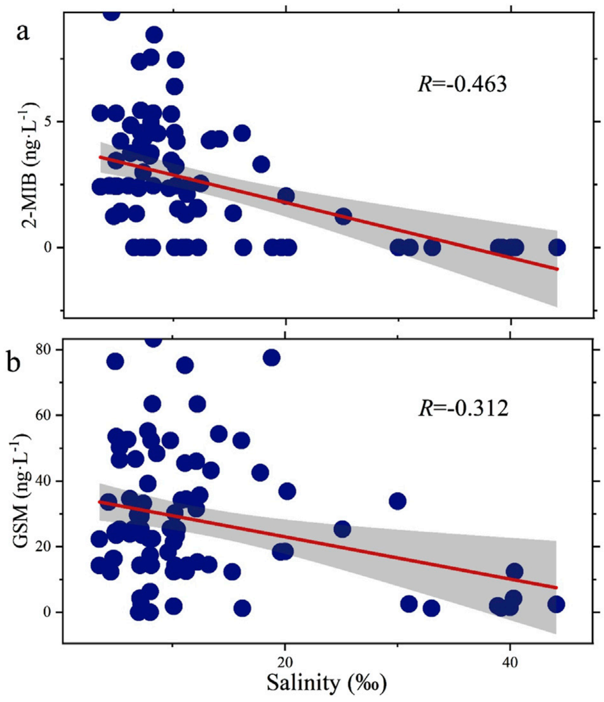

FIGURE 4
Relationship between 2-MIB **(A)** and GSM **(B)** and salinity in water samples, "R" is the Pearson correlation coefficient between them.

by COD, which in turn was correlated with TN and TP concentrations. Therefore, among the basic water quality indicators, TN, TP, and COD are strongly associated with the concentrations of two odor compounds, and these three water quality indicators also interact with each other (Figures 3B). TP also acts as a limiting factor for water eutrophication in many cases (Parinet et al., 2004), and the nitrogen and phosphorus content in the water column also directly determines the value-added of phytoplankton The nitrogen and phosphorus content in the water column also directly determines the rate of phytoplankton appreciation, which in turn affects the eutrophication process in the water column (Muhid et al., 2013; Sims et al., 2013; Vandergucht et al., 2013). In conclusion, TN, TP, and COD in water bodies can reveal the distribution of odor compounds in water bodies to some extent, but it is not certain that other water quality factors do not affect odor compounds due to the complexity of water quality changes, such as elevated temperature and dissolved oxygen, which can also affect other water quality factors.

Salinity also had a significant effect on the levels of odor compounds in the water column (Figures 3B; Figure 4), with correlation coefficients of −0.463 and −0.312 for 2-MIB and GSM concentrations, respectively, both showing relatively significant direct negative correlations and slightly greater than the path model coefficients between them (i.e., −0.401 and −0.299). The producers of 2-MIB and GSM in the water column, although slightly different, are mainly algae and bacteria (Wu and Duirk, 2013; Sauvé and Desrosiers, 2014). It has been shown that low salinity may promote the growth of algae, while high salinity shows some inhibition of algal growth, including many freshwater cyanobacteria, suggesting an indirect relationship between salinity and odorant substance concentration in the water column (Goncalves et al., 2006). However, this is not sufficient as a theoretical basis for a strong correlation between salinity and odor compounds, for example, the indirect correlation between factors such as TN and TP, which is more strongly correlated with algal bacteria, and odor compounds are abrupt. Since salinity is not all through indirect effects on algae and bacteria and thus inhibits the production of odor compounds in water, the direct significant difference between salinity and odor substances derived in the path model analysis ($p < 0.05$) may be that salinity directly destroys the persistence of odor compounds in water. Salinity mainly affects the ionic strength in the water column, while some related studies have shown that the higher the ionic strength in the water column, the more volatile the volatile substances in the water column, which likely include volatile odor compounds such as 2-MIB and GSM (Sauvé and Desrosiers, 2014; Baker et al., 2016; Watson et al., 2016). Moreover, the results of the separation analysis of odor compounds reveal that 2-MIB is more present in the dissolved fraction, while GSM is mainly present in the cells (Clercin et al., 2021), which explains well the greater effect of high salinity on the concentration of 2-MIB in water.

3.3 Tidal flat formation and regional salinity differences in relation to the distribution of odorants

Salinity differences in the water column not only indirectly affect the production of odor compounds, but also may be directly involved in the elimination or volatilization of odor compounds. It is difficult to verify the direct or indirect relationship through simulation experiments since the carrying capacity of odor compounds such as 2-MIB and GSM in the water column cannot be controlled. A large spatial scale study can eliminate the effects caused by chance errors between the independent and dependent variables. In addition to the distribution of odor compounds in water quality due to human activities, do natural geographic differences also affect the distribution of odor compounds in water bodies, e.g., does the formation of mudflats lead to different salinities in different waters, and what is the extent of the effect on the distribution of the corresponding odor compounds? We try to investigate the formation of mudflats and the distribution patterns of odor compounds in water bodies in different regions and their causes, by establishing a statistical study method at a large spatial scale.

Salt and freshwater mixing is a common natural hydrological phenomenon in estuarine waters. Freshwater runoff from rivers and seawater with high salinity are mixed with each other under the action of tidal currents in estuarine waters, and saltwater intrusion is formed upstream along the estuary at high tide. The formation of mudflats is the result of shoreline migration, and due to the difference in formation time and shoreline extension (Figures 5B), the salinity of mudflats varies from location to location. In this study, by collecting water samples from the coastal mudflats in Jiangsu province (Figure 5), the distance between the sampling point and the shoreline was measured using the sampling point as input elements and the adjacent actual shoreline as adjacent elements (Figures 5C). The results of the study showed that the salinity in the water body exhibited a distribution pattern of lower salinity in the water body at different locations of the mudflats, the further away from the present shoreline (Figures 5D).

In addition, the establishment of a larger spatial scale statistical study method (Figure 6), which focuses on a water environment with different salinities formed in different geographical areas, and the distribution of odor compounds in that water body as a study vehicle, helps to find the most concise relationship between the two variables. Wu (2021) in his studies of Fengman Reservoir (FMR), Miyun Reservoir (MYR), Tianmu Lake (TMH), Tangpu Reservoir (TPR), Qiandao Lake (QDH), Tingxi Reservoir (TXR), and Xinfengjiang Reservoir (XFJ), which the results are shown in Figure 6A–G and Figures 6A. It was found that the distribution of odor compounds in these seven large reservoirs had obvious differences. In TMH and TPR near the outlet of the Yangtze River, the concentrations of odor compounds were high, basically exceeding the olfactory threshold concentration of 10 ng/L. However, the species differed, with 2-MIB dominating in TMH and GSM almost undetected, while in TPR it was GSM dominating and 2-MIB at a lower concentration. The overall performance can be tentatively analyzed that the concentration of odor compounds in water bodies is higher the closer to the coast, which is also tentatively consistent with our predicted results. Moreover, the concentration of odor compounds in water bodies in the southern region is higher than that in the northern region. Since the coastal areas of China span three climate zones, warm temperate, subtropical, and tropical, and are gradually arid from south to north, the salinity of soil and water bodies increases from small to large accordingly. The salt content of the surface layer of coastal soils in southern China generally does not exceed 2%, while the salt content of the surface layer of salt soils in northern and northeastern China reaches 2%–3%, and even up to 5%–8% individually (Xu et al., 2013; Yu et al.,

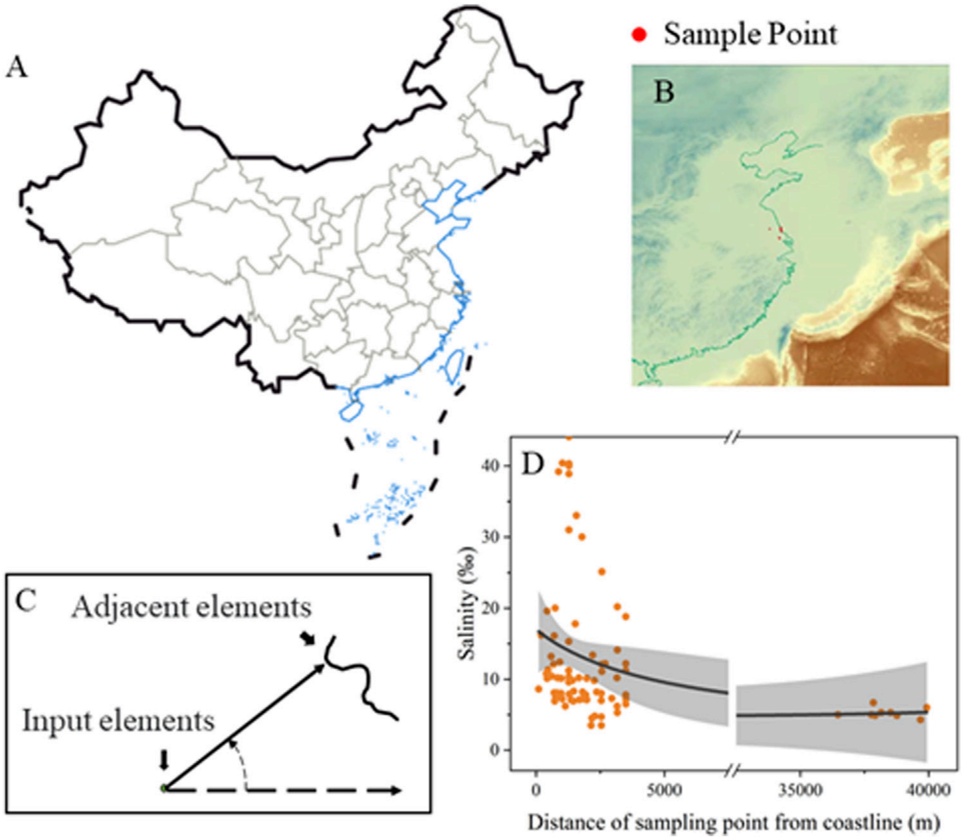

FIGURE 5
(A) is the map of China's coastline, **(B)** is the satellite map of China's coastline and the sampling site of water samples, **(C)** is the calculation model of the distance between the sampling site and the coastline, with the sampling site as input elements and the adjacent actual coastline as adjacent elements to measure the distance between the sampling site and the coastline. **(D)** represents the relationship between water salinity and distance from the coastline.

2014; Wang et al., 2018). This unique southern-northern difference is likely to be one of the dominant factors in the difference in the concentration of odor compounds in the southern and northern water bodies, and also mirrors our conclusion that salinity in water bodies is negatively correlated with the concentration of odor compounds.

We collected data from water bodies in the middle section of the South-North Water Transfer Line for statistical analysis (XIA et al., 2012). Since the water potential is flowing from south to north of the Yellow River (from S1 to S9 in Figures 6H), the odor compounds in its water bodies also show a trend of getting smaller from south to north during the water transportation (Figures 6B). In addition, the Yangtze River Delta and the Pearl River Delta regions, as the most economically developed regions in China, were studied by researchers on the spatial and temporal characteristics of salinity in the Yangtze River Delta inlet and the Pearl River Delta inlet, respectively, and it was found that the salinity in the water in the Yangtze River inlet (mostly higher than 31 during the flood season) was greater than that in the Pearl River inlet (9.95 during the flood season, with a concentration range of 0.03–31.72). Later, another researcher measured odor compounds in most water bodies (including reservoirs, lakes, etc.) in both regions (Figures 6C), and by comparison, it can be found that there are 14 water sources in the Yangtze River Delta where 2-MIB can be detected, and 76.9% of them have 2-MIB concentrations greater than 10 ng/L. There are 7 water sources where GSM can be detected, and all of their (Shi et al., 2019); 22 water sources in the Pearl River Delta region were able to detect 2-MIB, with all of them having 2-MIB concentrations greater than 10 ng/L, and 7 water sources were able to detect GSM, with 7.69% of them having GSM concentrations greater than 10 ng/L (Jia et al., 2011). In this larger spatial statistical study, the results were as we expected, i.e., waters with high salinity had lower concentrations of odor compounds in the water, although the differences may not be statistically significant. In the next studies, further validation is needed, as well as a more in-depth investigation of the direct and indirect effects of geographical differences and salinity differences on the distribution of odor compounds in water bodies, and their mechanistic mechanisms.

Odor contamination of water bodies has been taken seriously and how to go about identifying, measuring, and removing odor compounds such as 2-MIB and GSM from water is necessary to satisfy the end consumer. The taste and odor of water are now a global phenomenon, especially in the drinking water and aquaculture industries, which may cause concerns about the safety of drinking and food safety of aquatic products (Kakimoto et al., 2014; Zamyadi et al., 2015; Mustapha et al., 2021). More importantly, studies have demonstrated that odor compounds in water, such as 2-MIB, can be developmentally toxic to fish (Zhou et al., 2021). The removal of odor

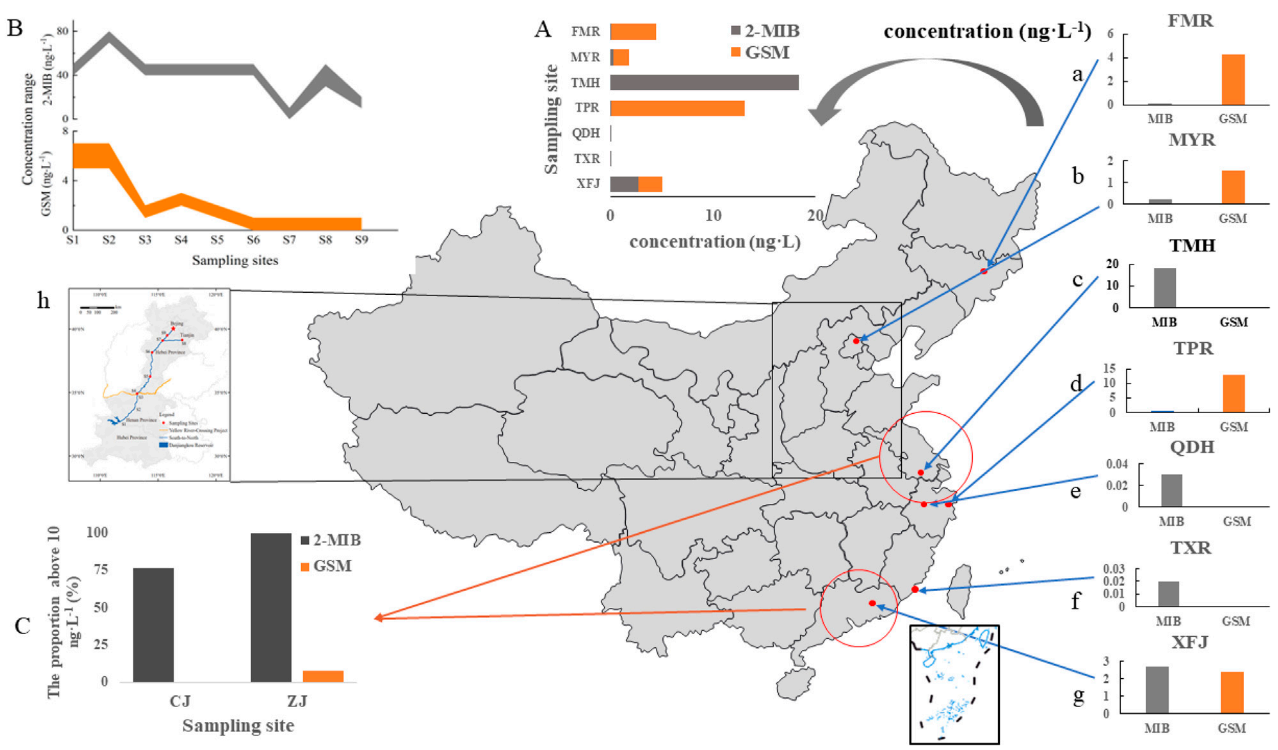

FIGURE 6
a–g represents the concentration of 2-MIB and GSM in Fengman Reservoir (FMR), Miyun Reservoir (MYR), Tianmu Lake (TMH), Tangpu Reservoir (TPR), Qiandao Lake (QDH), Tingxi Reservoir (TXR), and Xinfengjiang Reservoir (XFJ), respectively. **(A)** is the summary of the concentration of 2-MIB and GSM in these six water bodies (Wu, 2021). h is the middle route of the South-to-North Water diversion Project, in which S1 to S9 are the nine sampling points from southeast to north, and **(B)** represents the concentration range changes of 2-MIB and GSM in the nine sampled water (Wang et al., 2012). **(C)** represents the proportion of 2-MIB and GSM concentrations greater than 10 ng/L in the water sources of the Yangtze River and Pearl River Basin (Shi et al., 2019; Jia et al., 2011).

compounds in water, especially 2-MIB and GSM, is now a research focus, and different removal techniques using ultrafine powdered activated carbon (SPAC), coagulation, sedimentation, membrane filtration, flocculation, ozonation, powdered activated carbon (PAC), electrodialysis, sedimentation, co-precipitation, and multiphase photocatalysis have been applied to remove color, taste, or odor from water (Zamyadi et al., 2015; Fotiou et al., 2016; Guo et al., 2016; Garrido-Cardenas et al., 2019). However, all these methods have their inherent drawbacks. For example, the photochemical treatment with UV-assisted has a good removal effect for two pollutants, but it is not suitable for a large-scale replication due to the high cost (Huang et al., 2022). In recent years, with the increasing area of coastal mudflats, the management of mudflats has been paid more and more attention, as well as the high-speed development of coastal cities such as impact plains, the water quality requirements of this water body, have become more and more strict, and the rational use of its pollutant generation mechanism and potential degradation factors in the natural environment can be more efficient and targeted. Then, in addition to artificial removal, different waters can be managed in a targeted manner according to the geographical area, which can effectively solve the problem of odor pollution in water. For example, in coastal mudflat areas near the shore water sources and farming water, due to its salinity and other environmental factors inhibiting the residual odor compounds in the water, more attention can be paid to the control and removal of other pollutants as appropriate. In the management of waters in the north and south of China, the differences in water use characteristics and water environment should be treated differently. In the process of water management, we can pay more attention to the ecological safety of reclaimed water. For the management of southern waters, it is more urgent to prevent cyanobacteria outbreaks and eutrophication of water bodies. Secondly, in the development and use of coastal cities and mudflats, we should not only prevent the salinization of fresh water but also pay more attention to the odor pollution of water bodies.

4 Conclusion

In this paper, we take 2-MIB and GSM as the representative of odor compounds in water, and then explain the relationship between the basic water quality factors in water bodies and the distribution of odor compounds in water as an expansion, extending an interesting phenomenon that salinity in water samples, compared to other water quality factors, shows a particularly negative correlation with the concentration of odor compounds in water, showing a clear direct relationship. This is somewhat different from many studies that have concluded that water quality factors indirectly affect the distribution of odor compounds by influencing the producers of odor compounds in water, such as cyanobacteria and actinomycetes. Salinity in water may reduce the concentration of odor compounds by inhibiting their retention in water. This conclusion was confirmed by a statistical study on a large spatial scale to investigate the differences in the distribution of odor compounds in coastal areas of China and in northern and southern waters and to compare them with salinity. The salinity of water plays a key role in the variation of odor compounds concentration. In the process of future water management, the management of different geographical locations and different water environments should be targeted to enhance management efficiency, improve water quality, and solve the problem of odor pollution in water more efficiently and conveniently. It will point out a new guiding direction in the more effective development and utilization of impact plains and coastal mudflats.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding authors.

Author contributions

XC: Investigation, Methodology, Writing–original draft. ZL: Investigation, Methodology, Writing–original draft. HX: Validation, Writing–review and editing. LQ: Supervision, Writing–review and editing. LF: Supervision, Writing–review and editing. SM: Supervision, Writing–review and editing. ZG: Writing–review and editing. CS: Funding acquisition, Project administration, Writing–review and editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

Supplementary material

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fenvs.2024.1433586/full#supplementary-material

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