Geographical distribution of general aerobic heterotrophic bacteria in surficial sediments from the Chukchi Sea and Canadian Basin

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Abstract This paper determined the abundance of General Aerobic heterotrophic Bacteria (GAB) in surficial sediments from the Chukchi Sea and the Canadian basin by using MPN and discussed their geographical distribution. The result shows that the determination percentages of the GAB were high, even till 100 percentage. The abundance range and averages of GAB for 4℃ and 25℃ were from 4.00 × 10^2 to 2.40 × 10^6, 1.71 × 10^6 ind · g^{-1} (wet sample) and from 2.40 × 105 to 2.40 × 10^7, 1.10 × 10^7 ind · g^{-1} (wet sample) respectively. Not only the abundance range but also the averages of GAB in 25℃ were higher than that in 4℃. The abundance of GAB in sediments show a tendency that it is roughly greater in the lower latitudinal area than in the higher latitudinal area. The abundance of GAB increased from east to west as for the longitudinal distribution. With the water depth increasing, the abundance of GAB at 4℃ decreased, but GBA at 25℃ is not changed obviously with water depth. It seems that warmer circumstantial temperature is more suitable for some GAB.
Key words the Arctic Ocean, the Chukchi Sea, the Canadian Basin, General Aerobic Heterotrophic Bacteria (GAB), geographic distribution

1 Introduction

Although the Arctic Sea area is permanently cold, there are prominent general aerobic heterotrophic bacteria (GAB) distribution in the Arctic seawater and sediment similarly to other oceans. The cosmopolitan of GAB, its large magnitude and biodiversity make GAB take an important role in characteristic forming of environment including the Arctic area. The importance of GAB in environment includes material transportation, energy transition, cycle of ecosystem, rehabilitation of destroyed-environment, supply for human as resource of sustainable utilization and so on. Marine surficial sediment, as the interface between bottom water and sediment, has a twofold request for marine bacteria, i.e. it requests marine bacteria not only adapt to bottom water, but also to oxygen-limited sedimental environment. With respect to the Arctic Ocean, it should be adapted permanently cold environment. The Arctic sea nourish many adaptive bacterium species, including lager amount of GAB, and is not a "desert" as described before[1].

The studies on bacterium content in the Arctic Ocean can be traced back to the mid or late of last century, such as Kaneko *et al.*, who researched bacteria in the Arctic, subarctic and Beaufort Sea[2, 3, 4]. During the last decade, such as Sahm *et al.*, Rysgaard, Hagstrom *et al.*, Soltwedel *et al.*, Ravenschlag *et al.*, Junga *et al.*, Ye De-Zan *et al.*, Chen *et al.* studied marine bacteria in different part of the Arctic ocean[5-12]. The improvement of research methods has been made by many researchers[8, 10, 13, 14]. Researchers analyzed the distribution characteristics and behaviors of GAB in marine sediments in different aspects, which included abundance, geographic distribution, adaption to temperature, activity, biomass, structure of community, diversity, productivity, connection with environmental organic matter, mineralization etc. Research areas were distributed all over the Arctic area, which brought in some production for understanding more about the condition of the Arctic seabed microbe. But correlative research in China is very limited[12].

In this paper, the occurrence percentage and abundance of GAB in surface sediment samples of Chukchi Sea and Canadian basin are analyzed by MPN for a geographic research of bacteria, and also discuss the ecologically geographic distribution of GAB.

2 General information of research area

Research area is located in Chukchi Sea and Canadian basin (66°-80°N, 148°-170°W) and near the side of the Asia-America continent, which is more extensive than that of first Chinese Arctic Research Expedition. Because of the influence of Bering Strait, sediments in research area contain rich nutrition matter. Selected 24 samples from 43 samples for bacteriological analysis, and location of sampling stations can be seen in figure 1.

3 Sampling

Samples were collected by Xuelong expedition ship during the second Chinese Arctic Research Expedition from July to September, 2003. After being taken onboard the ship, surface 0-1 cm samples were collected immediately and stored in icebox for microbiological analysis in the domestic laboratory.

4 Analysis in the domestic laboratory

Microbiological analysis was started in January 2004. The liquid culture medium plates used were ZoBell 2216E plates, the specific components and preparing method were as those as in referenced paper[15]. Selection of culture temperature followed the study result of first Chinese Arctic Research Expedition[12]. Based on MPN, 1g from each wet sample was taken quantificationally and diluted to specified concentrations series, respectively[16]. The samples were then cultured in plates for over 3 weeks at 4℃ and 25℃, respectively. During culture period, samples were observed at intervals to ensure turbidity or precipitation/bacteria film appeared in tubes as positive. Content calculating was based on GB/T4789. 3-2003[17], and the content as well as the occurrence percentage of GAB was calculated, their distributions were discussed.

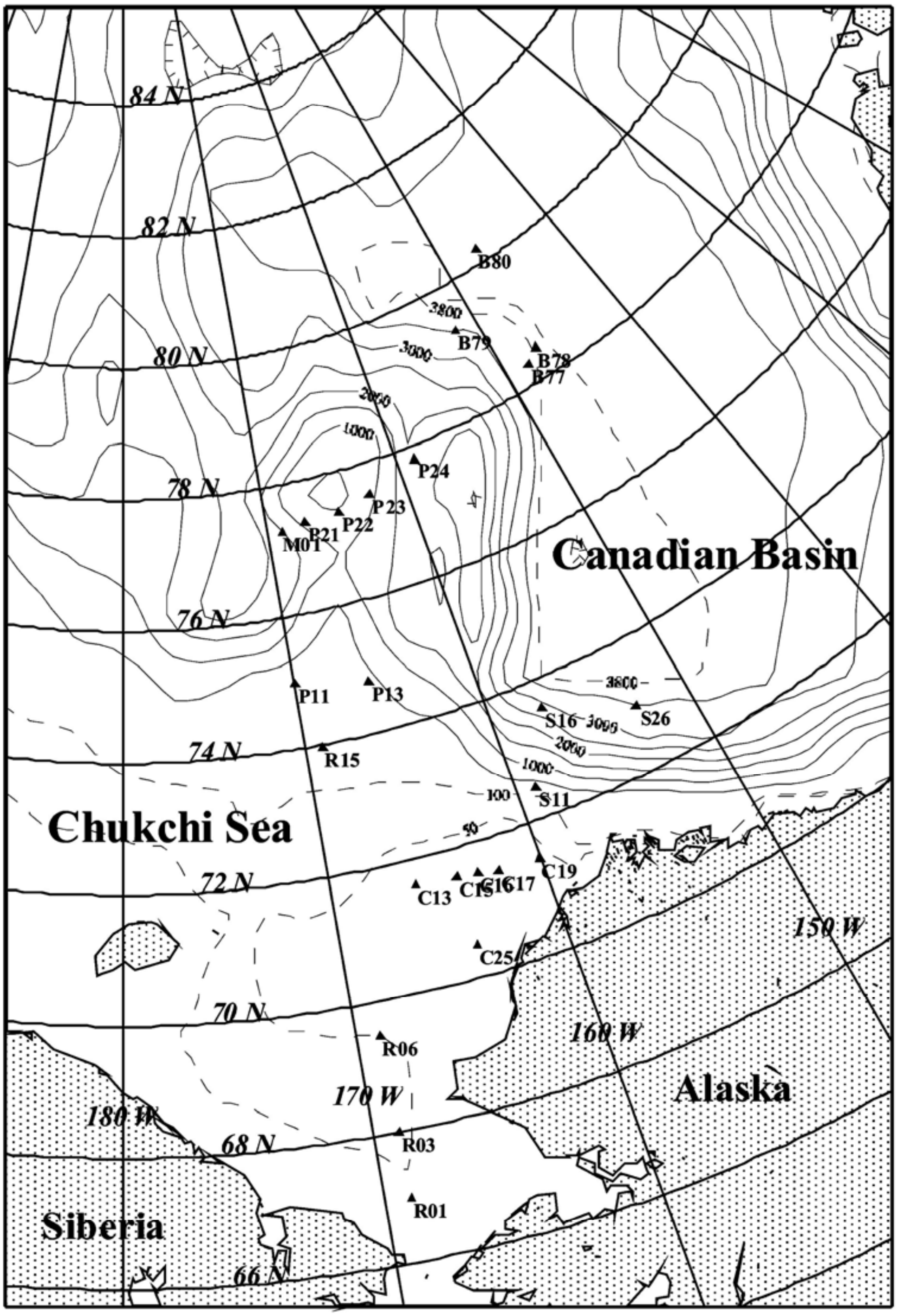

Fig 1 Sketch of sampling stations for GAB in surficial sediments from the area surveyed in the Arctic Ocean

5 Results and Discussion

5.1 Content and Occurrence Percentage of GAB

GAB content at 4℃ and 25℃ are listed in Table 1. It can be calculated by using the data in Table 1 that the overall occurrence percentage of GAB in the sediment samples at all survey sites is 100%, which implies GAB are fairly ubiquitous within our study area and maybe in the whole Arctic ocean. The statistical results show that the overall average abundance of GAB at 4℃ is 1.71×10^6 ind • g^{-1} (wet) with a range from 4.00×10^2 ind • g^{-1} to 2.40×10^6 ind • g^{-1}, and the overall average abundance of GAB at 25℃ is 1.10×10^7 ind • g^{-1} (wet) with a range from 2.40×10^5 ind • g^{-1} to 2.40×10^7 ind • g^{-1}.

Not only content range, but also average abundance at 25℃ are greater than that at 4℃. GAB content of this study is greater than that of first Chinese Arctic Research Expedition[12], but is lower than that of Ravenschlag[9] which was carried out along Svalbard island using molecular biological method. Compared with that in the cases of China seas, the only GAB data of which is that of Sang-Gou bay in Shandong province[18], the results are lower.

Table 1 Content of GAB in surficial sediments from the area in the Arctic Ocean

Station	Depth/m	4℃	25℃	Station	Depth/m	4℃	25℃
R01	50	2400000		R15	175	240000	
R03	55	2400000		P13	453	440	
R06	53	2400000		P11	263	240000	24000000
C25	41	1100000		M1	1456	240000	240000
C19	50	240000	240000	P21	561	400	
C17	46	24000000		P22	326	240000	
C16	43	240000		P23	2200	24000	
C15	42	2400		P24	1880	2100000	2400000
C13	44	240000		B77	3850	24000	
S11	50	2400000	24000000	B78	3800	24000	
S26	3000	13000		B79	3800	110000	
S16	3800	2400000	2400000	B80	3750	70000	24000000

* unit ind • g^{-1} (wet sample)

5.2 *Variation of GAB content along latitude*

Divided study area into 4 zones by a interval of 4°, which included 66°– 70°N (3 stations), 70°– 74°N (10 stations), 74°– 78°N (7 stations) and north of 78°N (4 stations). Then the figures of GAB content distribution were drew along latitudes were drawn (fig. 2). Fig. 2 shows that at 4℃ GAB content decrease with latitude increase, which is consistent with that of First Chinese Arctic Research Expedition[12]. The data at 25℃ is few, with 3 stations between 70°– 74°N, 3 stations between 74°– 78°N and 1 station farther north than 78°N. The distribution of GAB content at 25℃ within 70°– 74°N and 74°– 78°N are similar, and maximum of 3 latitude interval are fitly same, which is 2.40×10^7.

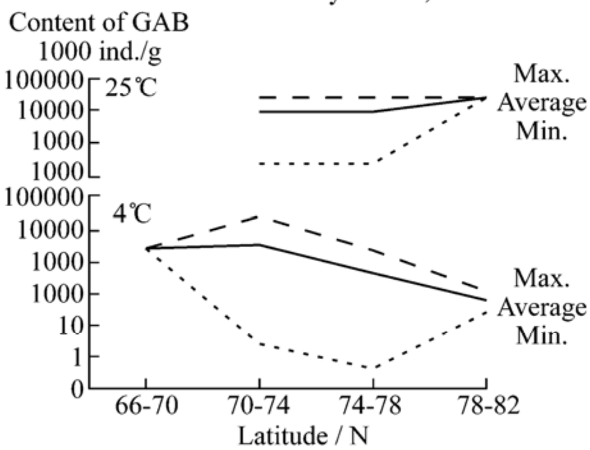

Fig. 2 Comparison on content of GAB in surficial sediments among latitudes surveyed in the Arctic Ocean

5. 3 Variation of GAB content along longitude

As for longitudinal distribution, the research area was divided into 5 zones by a interval of 5°. The first two zones 145°–150°W and 150°–155°W within Canadian Basin, include 5 stations. 155°–160°W zone within the continental slope of Canadian Basin, distributes 3 stations. 160°–165°W within eastern part of Chukchi sea has 7 stations, and 165°–170°W within the middle part of Chukchi sea accounts for 9 stations. Variations of GAB in each longitude zone are showed in figure 3. Averages and maxima of GAB content in 5 longitude zones show that at 4℃ GAB content decrease from west to east. The number of samples at 25℃ in 5 longitude zones from west to east is 2, 1, 3, 0, 1. Nevertheless, GAB content in 5 longitude zones vary lesser, except station C19 (2.40 × 10^5 ind • g^{-1}) within the east part of Chukchi sea where the GAB content is relatively low.

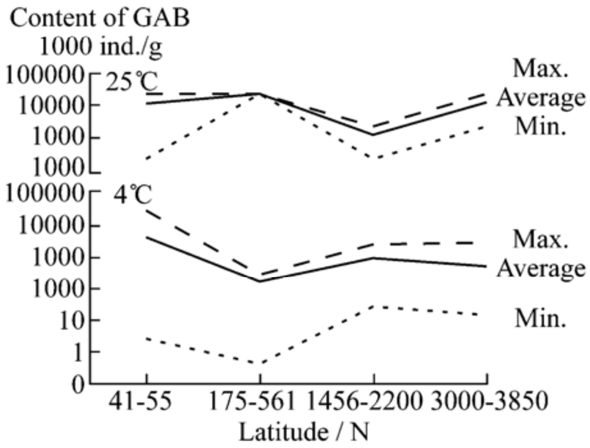

Fig. 3 Comparison on content of GAB in surficial sediments among longitudes surveyed in the Arctic Ocean

5. 4 Variation of GAB content with water depth

All water depths of sampling were divided into 4 groups which include 41-55 m, 175-561 m, 1456-2200 m and 3000-3850 m. The number of sample within each group at 4℃ and 25℃ is 10, 5, 3, 6 and 2, 1, 2, 2, respectively. Figure 4 shows distribution of GAB content at different water depth.

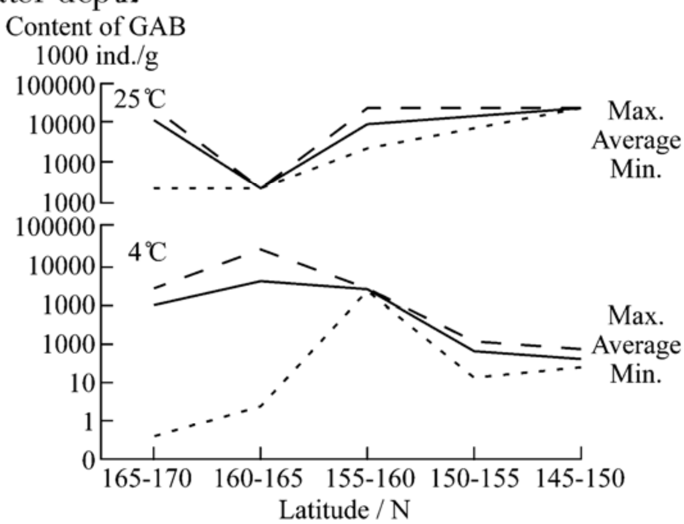

Fig. 4 Comparison on content of GAB in surficial sediments among different water depths in the Arctic Ocean

As showed in figure 4, at 4℃ average content of GAB descend jumpily with water depth, which present as maximum-low-high-lowest. Minima of GAB content change as low-lowest-highest-high, and maxima of GAB content vary as highest-lowest-high-higher. However, all conditions at 25℃ run in opposite sequence.

As a result of larger effect from environment and nutrient matter within continental shelf, at 4℃ GAB content vary observably, with maximum (2.40×10^{7} ind • g^{-1}) appears at station C17. The rest stations all higher than 2.40×10^{5} ind • g^{-1} except station C15 (2.40×10^{3} ind • g^{-1}). So, the maximum average GAB content appears within the shallowest continental shelf, which is 3.54×10^{6} ind • g^{-1}. The layer of 175 m-561 m depth has the lowest GAB content among 4 groups, with a range from 4.00×10^{2} ind • g^{-1} to 2.40×10^{5} ind • g^{-1}. Significant environment effect and low nutrient matter supply may be the main reason which contributes to the appearance of lowest GAB content. The GAB content within the rest two deeper depth intervals is 2.40×10^{4} ind • g^{-1} ~ 2.10×10^{7} ind • g^{-1} and 1.30×10^{4} ind • g^{-1} ~ 2.40×10^{6} ind • g^{-1}, respectively. Because of little effect from environment, GAB content distribute relatively uniformly.

At 25℃, only one data located within the depth interval 175 m-561 m, and its value is 2.40×10^{7} ind • g^{-1} which is equal to the maximum appears in interval 41-55 m and interval 3000-3850 m, but is one-magnitude-order larger than the maximum of interval 1456-2200 m. The rest 3 depth intervals have 2 data, and the minimum of the 2 data is 2.40×10^{5} ind • g^{-1} which appears both in interval 41-55 m and in 1456-2200 m. So, it is concluded that at 25℃ GAB content has weak or no relation with water depth, and the GAB content in interval 1456-2200 m (continental slope) is relatively low.

In conclusion, control factors on GAB content of surface sediments within the Arctic Ocean are complicated, because GAB content does not consequentially vary with water depth.

5.5 *temperature effect on GAB content*

Samples were cultured at 4℃, 15℃, 25℃ and 28℃ separately during the research in First Chinese Arctic Research Expedition[12]. Experiment indicates that most of GAB are favorable for living at lower temperature and about one third of GAB are suitable for living at higher temperature (25℃ to 28℃). In the study, only 4℃ and at 25℃ were selected, then not only content range, but also average abundance at 25℃ are greater than that at 4℃, and the results are greater than that of first Chinese Arctic Research Expedition. More strict sampling and preservation method were adopted in this study. In addition, the results also show the interaction between bacteria and temperature, namely, temperature choose bacteria and bacteria select the adaptable temperature. It is shown in the experiment results that the bacteria in the Arctic sea area have considerable adaptability to the environmental temperature. Surface sediments in our study area contain large amount of psychrophilics bacteria, and also include some mesophilic bacteria.

Unlimitedly, global climate change and ocean flows warming caused by excessive carbon emission also influence Arctic Ocean, although it has a huge self-adjusted ability. This study has a clear elevation on temperature of bottom water and salinity compared with that of first Chinese Arctic Research Expedition, and maximum, minimum get a rise, too[19]. These changes of environment certainly will impel microbe to adjust themselves to adapt new environment. Water temperature affects life activity and metabolic rate of bacteria directly, and then affects the biogeochemical processes. It may imply that the environment changes of the Arctic Ocean must be thought about much more.

Based on above analysis, it be concluded that GAB is mainly controlled by material sources and ecological environment. Organic matter brought in through Bering Strait, by the east Siberia coast current and Mackenzie River is the main factor in restricting GAB distribution. Water depth, water temperature and genus of microbe also influence GAB distribution. Relative researches remain to be further studied.

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