Study on air anion concentration distribution in Beidaihe, China

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Abstract. In this paper, the air negative ion concentration distribution map in Beidaihe district was summarized and completed through several field visits to some representative areas in Beidaihe district or collection of local air detection data over the years. Combined with geomorphic environment, climatic conditions and other factors, this paper analyzes the regularity and characteristics of the concentration distribution of air negative ions in beidaihe, and proposes to build "the Great Wall of Air negative ions".

1. Introduction: The discovery and development of negative ions
Air anion is a natural state, in the air environment with a negative charge of gas molecules or molecular groups. J. Thomson first expressed the characteristics of ions with formulas and established the models of positive ions and negative ions. Eiseer and Geieel then demonstrated the existence of ions, positively and negatively charged particles that are slightly larger than the size of the molecule (Figure 1). In the late 19th century, Philip Lionad [1] (German physicist) was the first to academically demonstrate the effect of negative ions on the human body. He suggested that negative ions in the natural environment were beneficial to human health, and pointed out that the highest concentration of negative ions was around the valley falls. By 1902, Aschkinass and Caspari had confirmed the biological significance of the existence of air negative ions. In the early 20th century, Russian scholars first published the theory of using negative ions to treat diseases. In 1932, the United States RCA hamerson invented the world’s first medical air anion generator. Since half a century ago, the research on air anion has experienced a long period of development and application in Europe, the United States and Japan.

2. The generation of air negative ions and its biological significance to human body
2.1 The mechanism of negative ions in nature [2]
There are several mechanisms for the generation of negative ions in nature:

Ray and tip discharge. In the natural world, positive and negative ions of air are generated by ultraviolet rays, cosmic rays and other various rays, which are constantly generated and disappeared to maintain a certain dynamic equilibrium state. At the same time, due to the electrostatic field formed by the ground for the atmospheric ionosphere, the ground is the negative pole, the air negative ions are repelled by the ground, and the positive ions of the air are attracted by the ground. Therefore, under
normal circumstances, the ground positive ions are more than negative ions, the positive and negative ion concentration ratios are often greater than one, and the positive and negative ion concentrations are each about 400–700/cm³.

![Figure 1. Structure model of air](image1)

**Figure 1.** Structure model of air

![Figure 2. Brief history of anion development in modern times](image2)

**Figure 2.** Brief history of anion development in modern times

*Plant photosynthesis.* The photosynthesis of plants is the process of converting the absorbed solar energy into carbohydrates and oxygen by using carbon dioxide in the air and water in the soil, and releasing electrons, i.e., negative ions, during this conversion.

*Physical effects (tidal action, waterfall effects).* The formation process of ions is that much particulate matter is rubbed by air, and the electrons in the atomic structure are forced to transfer to form charged ions. The water flow collides and rubs against the liquid itself and the air during the falling or irregular flow, and the droplets generate gaseous negative ions due to the shearing force, so that an atmosphere rich in water and negative ions is formed around the waterfall. This mechanism, also known as the Lenard effect, can be expressed by the following equation:

\[ \begin{align*}
H_2O & \rightarrow H_2O^+ + e^- \\
H_2O + e^- & \rightarrow H^- + OH \\
H^- + H_2O & \rightarrow OH^- + H_2 \\
OH^- + nH_2O & \rightarrow OH(H_2O)_n
\end{align*} \]  

It can be summarized as: \((H_2O)_n \rightarrow (H_3O^+)(H_2O)_{n-m} + OH(H_2O)m_2 (n>>m)\).
2.2 Several methods for artificially generating negative ions

The "corona discharge type" which breaks through the air insulation by applying a large voltage to the humidifier;

"Ray line" of negative ions generated by the radioactivity of radioactive minerals;

Like a waterfall by the energy of the wave impact of negative ions generated by the "wave type";

"High-energy" metastable polymer composites prepared from natural ores. The theory of "ionized air" [3] was proposed and formed. On the one hand, air negative ions were generated by artificial methods under artificial conditions. On the other hand, the utilization of air negative ions has entered a new stage by applying the physiological effects of naturally formed air negative ions under natural ecological conditions. As far as the above types of artificial anions are concerned, "corona discharge" is more and more widely used in household appliances. The negative ions of "wave type" come from nature, but their release efficiency is low. The method of preparing air negative ions through micro-electrolysis of natural ore technology has the characteristics of high efficiency and safety, and more and more attention has been paid to it.

2.3 Biological significance of air negative ions on human body

Anion is a natural reducing agent with biological safety. The content of anion in air is also an important reference index for air environment in various areas. As an "air vitamin", negative ions have many functions and have good effects on the human body and even all living things. Their presence will help the human body to return to the natural balance state. The molecular formula for air anions is $O_2(H_2O)_m$, $OH(H_2O)_m$, $CO_3(H_2O)_n$, and the atom is made up of positively charged nuclei surrounded by electrons. If the air contains too many positive ions or too few negative oxygen ions (<800/cm$^3$), the air enters the body and stimulates the production of serotonin by platelets in the blood, which is then transported through the circulatory system to the tissues of the body. Serotonin prevents the absorption of oxygen (typical symptoms; Fatigue, dizziness, migraines, inattention, depression, and shortness of breath can be offset by the entry of 1,200 cm$^3$ of air into the body). When negative ions enter the body through the mouth, nose or directly through the skin, they cause the breakdown of 5-hydroxytryptophan into a nontoxic by-product, 5-hydroxyindoleacetic acid, which is excreted in the urine to eliminate the harm. When negative ion enters human body, still can cause a series of benign reaction. The most obvious: (1) Activate cell vitality, maximize the play of the physiological function of the organs, repair the damaged body, etc.; (2) Negative oxygen ion on the human body has the regulation of central nervous system activities, improve the function of coronary blood flow, but also promote the bronchial cilia movement;
(3) Prevention and treatment, improve respiratory diseases; (4) Regulate hormone secretion and cell potential, promote endocrine and metabolism, improve immune function and resistance to disease. Anion still has eliminate nervous, composed, awake effect, can raise office efficiency. Be in for a long time in relatively good anion environment, to stabilize the person’s mood, restore physical strength, prevent and treat certain disease, wait like spirit depression, hypertension, asthma, coronary heart disease, very beneficial.

3. Influencing factors and detection methods of air negative ions

3.1 Influencing factors of air negative ions under natural conditions
From the analysis of geographical latitude, the concentration of air negative ions on the ground depends on geographical factors (waterfalls, beaches, canyons, rural fields, suburban wilderness, towns, etc). Due to geographical differences, as long as there are similar geographical factors, they all present regular distribution [4]. Air anion concentration refers to the number of anions in the air per unit volume, which is expressed in units/cm$^3$. The number of air negative ions in waterfalls and beaches is usually kept at more than 10000/cm$^3$, canyons and streams are usually kept at more than 1000/cm$^3$, suburbs, villages and forests are kept at more than 2000/cm$^3$, and the content of air negative ions in waterfall mouth is often higher, the highest is close to 40000/cm$^3$. For the urban environment, the trees and green spaces are significantly less than the suburbs and villages. The roads in the urban areas are mainly cement and asphalt roads, which block the ionization source from the soil. Therefore, the urban air negative ion concentration is much lower than that in the suburbs and rural areas. Under normal circumstances, the air anion concentration is negatively correlated with the fine particulate matter PM2.5 and the concentrations of SO$_2$, NO$_2$, and CO, and positively correlated with the ozone concentration. The number of negative ions in urban streets is 100–200/cm$^3$, while the average number of negative ions in typical residential rooms in big cities is only 40–50/cm$^3$.

From the perspective of time dimension, the annual change of air negative ions is also significantly different. Due to the large amount of data needed to study the annual change of air anion concentration, systematic data in this respect is relatively scarce. According to the research of some scholars, generally speaking, the concentration of negative ions in urban air is the highest in summer and the lowest in winter, followed by spring and autumn.

3.2 Detection method of air negative ion concentration[5]
The institute of Boyan material design and research in Yanshan university national university science park, Qicai technology of Yanshan university, Polymer innovation of science and technology research institute and Qinhuangdao, keep natural nanotechnology research based on years of release anion material research, the first in February 2008 to Beidaihe environmental protection bureau to air ion concentration observation of district, and published the Beidaihe district air index observation data. This instrument is a DLY 6A2 type air ion measuring instrument (Figure 4) and a WST-08 type atmospheric negative (oxygen) ion measuring instrument (Figure 5).

The air ion meter uses a capacitive air ion collector to collect the charge carried by the air ions. The ion concentration can be converted by measuring the current generated by these charges and sampling air flow. Each air ion is thought to carry only one charge. In the measurement process, the positive and negative air ion with the sampling flow into the collector, under the influence of polarization electric field, ions through the gas when the average speed of (that is, the migration velocity) not only have close relationship with ionic diameter (ion is smaller, the faster), and is proportional to the polarization voltage of electric field intensity, this proportion is called ion mobility. By changing the mobility, different ion concentrations can be measured.

According to professor Li Qingshan of Yanshan university, the seven levels of air negative ion concentration are related to human health [6]. To determine air quality and air freshness, as shown in table 1.
4. Study on air anion concentration distribution in Beidaihe[6]
Professor Li Qingshan’s research group from 2008 to 2018, field inspection of several representative areas of Beidaihe in Qinhuangdao, integrate air negative ion concentrations under various conditions to exclude data from extreme individual cases, take the average stable value as follows (Table 2), and draw the “Beidaihe air anion concentration distribution map” (Figure. 6).

Table 2. Relationship between seven levels of negative ion concentration and human health

| Location                | Negative ion concentration mean (pieces/cm³) | Remarks                                                      |
|-------------------------|---------------------------------------------|--------------------------------------------------------------|
| Olympic Park            | 100-500                                     | There are 5000 waterfalls/cm³ in the landscape³               |
| City Center             | 160-500                                     | The downtown waterfall can reach 10,000/cm³                   |
| Geziwo                  | 1100-3000                                   |                                                             |
| Lianfeng Mountain Park  | 1100-10000                                  | The peak reached 15,000/cm³                                 |
| Biluota Park            | 2100-3000                                   |                                                             |
| Laohushi Park           | 2000-3000                                   |                                                             |
| Jifaguanguangyuan Park  | 1000-3000                                   |                                                             |
| Bird watching wetland, lianfeng river estuary | 2000-5000                               | The highest value of 36500/cm³ was measured on September 16, 2008 |
Through observational data analysis, preliminary conclusions can be drawn: Beidaihe is located in the northeastern part of Hebei Province, China, backed by Lianfeng Mountain (130 meters above sea level), and the lower-lying beaches go straight into the middle of the northern shore of the Bohai Bay. Therefore, the annual warm and humid coastal monsoon circulation continues. Bringing fresh and humid air to Beidaihe District, the annual average humidity can reach about 65%. The air anion concentration in the coastal area is mostly maintained at 2000/cm$^3$ or above. It is located in the “Bird Watching Mecca Wetland” on the Beidaihe Forest Wetland Waterfront. When the weather is fine, the air anion concentration can reach 5000/cm$^3$, so the waterfront and the suburbs The landscape area is an enriched area of air anions. Under normal circumstances, the air in the urban area is not affected by the production and life, and the concentration of negative ions in the air is not high. In particular, the harmful gases such as nitric oxide generated by the transportation system will rapidly react with the negative ions in the air, so the air negative ion concentration during the peak traffic period is Minimum value [7]. In general, the average value of air negative ion concentration in Beidaihe is more than 2000/cm$^3$, the highest value is over 10000 (the peak of Lianfeng Mountain), and the minimum value is 100/cm$^3$, which compares the air negative ion concentration distribution in the country (Figure 7 Air anion concentration distribution map of China), Beidaihe has exceeded the national average level, and is also one of the regions with the best air quality performance in the offshore cities of the North.

According to Beidaihe test of air negative ions distribution and forest air negative ions distribution characteristics such as research and analysis, relying on the unique ecological environment of the local conditions, with the concept of “negative ions build a healthy Great Wall”, use negative ion material or artificial anion generation model to strengthen and transform the city, the construction of the densely populated areas, such as using anion asphalt paving [9–10], using anion anion health paint coating and painting the walls, laid floor, equipped with air anion anion humidifier, etc., at the same time, in the scenic spot environment relatively weak anion local construction some landscape fountain, using geographical advantage to build artificial waterfalls, etc., to improve the concentration of negative ions in the air, to meet the needs of the health of natural air, make visitors get relax in tourism and health care effect. At the same time, it can also label and negativeize the "Air anion enrichment area", further strengthen the Beidaihe tourism resources gravitational radiation ability, create first-class tourist livable cities.
Figure 7. Air anion concentration distribution map of China

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