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UNITED STATES ARMY
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The Germ Content of the Atmosphere.

by Hellmut Reifferscheid

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A certain part of the atmospheric aerosol consists of organic substances and microorganisms. This part is subject to fluctuation, however; it is possible therefore to establish a spectrum of organic admixtures analogous to a physical spectrum of sizes as found for instance in Junge (1). An example of this spectrum is shown in figure 1, all organisms listed here are usually found also in the atmosphere.

They include both living, primarily plant organisms, and also viable organisms in the form of pollen and spores of higher and lower plants and fungi. Their mere occurence can influence human well-being due to their specific allergic action,i.e. Hay Fever. They are also seen frequently in the form of real "clouds". One is reminded here of clouds of acacia flowers or of those yellow pollen clouds which may separate from hillsides overgrown with spruce or pine,as recently described in the literature.

The relationship between pollen content and the source of an air mass is being investigated in cooperation with the Botanical Institute of Würzburg University and the Director of the Würzburg Weather Station, Dr. Weiss. Flower pollen of all kinds range in size from a few microns to several hundred microns, the rates of decent found here are low, their specific gravity is usually below 1, since we are dealing here with dried organic cell tissue. This causes the flower pollen to be carried across several hundred kilometers and thus allows an analysis of the air mass by the botanist and the bio-climatologist.

In this sense the conditions are even more favorable in connection with the bacterial content of the air. Without a doubt, this content changes with the source and the history of an air mass. Thus, for example, an air mass that originally left the Sahara and reached us via the Balkan peninsula, will show a much higher bacterial content than one that came to us from the polar region across the Arctic Ocean. The decisive role is played here by the positions of the air streams in relation to continents and oceans, since these regulate the available supply of all types of germs coming from the ground.

It may be expected theoretically that the maritime polar air masses are poorer in bacteria than the sub-tropical continental (the classification of air masses is according to LINKE-DINIES). Optimal living conditions of bacteria can be found only at relatively high air temperatures and humidities together with an available supply of germs from the substrate. The actual manner in which the influence of continentality is revealed in the origin of the air mass cannot be predicted. Without a doubt, the germ supply on the path described by the easterly winds is much higher than that available to the westerlies coming from the ocean. At the same time the influence of greater dryness in the air of easterly winds on the growth and viability of germs cannot be underestimated.

Our own test results seem to confirm these relationships, see Table 1. However, a conclusive judgement cannot be made due to the small number of measurements made so far. Moreover, there probably will be gradual differences during the course of the year which can only be supported by a large number of measurements.

A discussion of this problem known to most bio-climatologists, namely Marteni's "The Ways of Epidemics" has treated these questions years ago although on a larger scale. That, for instance, they must not be confused with all those climate connected epidemics in which the favorable living conditions brought about by the weather allow a particularly strong reproduction among host animals which act as vectors of the pathogens. I am reminded here of typhus epidemics, for instance, during the last war in which the connection with the weather is primarily through the clothing that protects against the cold but which is changed infrequently and does give the lice an opportunity to act as vectors of the bacilli. The situation is somewhat similar in the case of epidemiologically appearing Marsh Fever among pea pickers (2). Here again the weather is the primary cause by allowing a strong reproduction among field mice during the dry summers. The animals are frequently infested with the pathogen, a ray fungus, which evokes kidney disease in them. During the animals' search for food these are deposited on the crops and reach the pickers from there. Thus the epidemic which is approximately 20% lethal is dependent on the climate but is disseminated not only thru the medium of the air but thru an animal.

It would be interesting to follow the relationship between air mass, weather and virus in order to clarify influenza infections appearing in the form of epidemics in which the connection with the weather was proved among others by F. Baur (3). However, test methods are made difficult here and become unduly expensive since the cultivation of viruses is possible only in the living animal.

For this reason the present study was to investigate the relationship between air masses and bacterial content.

I have described the actual test method elsewhere, namely in the "Weick Mann Issue" (4) to which the reader is referred.

The actual apparatus which works on the conimeter principle resembles H. Falke's air sampler (5) although both pieces of apparatus were developed independently of each other. The Petri dishes used in these two instruments are of different size, however; while Falke uses dishes with a diameter of 22 mm our apparatus works with dishes of 100 mm diameter which is the customary size in bacteriological work. We also deem the latter more favorable for reasons of perspective. During measurements the petri dishes rotated under the conimeter slit producing a circular deposit of germs and bacteria. See Figure 2.

Another very important advantage of our apparatus compared to all others consists in the use of a so-called humidity flue as used for the first time by Junge (6), to increase the absorptive power of the aerosol on hydrophobic smooth surfaces. During their passage thru this flue all particles are increased in size by swelling or by absorbtion of water on their surface. This increases their weight which in turn increases the centrifugal power which works in the strongly bent air passage below the slit. This also increases the probability that the particles will be deposited on the surface of the agar. Tests with and without this humidity flue confirmed these considerations; however, they also showed that the necessity for the use of this flue is superfluous at relative humidity above 85%. This special arrangement produces concentrations that are 2 to 5 times higher than before.

All measurements made to date are applicable to open air. They were carried out on the roof of the Technological College Darmstadt at a height of about 23 meters. It seems that the germ concentrations during the course of the year are subject to seasonal fluctuations as can be expected. These fluctuations correspond to changes in temperature and humidity during that period. Thus, for instance, much higher concentrations are measured in the summer months than in the fall.

Other results are expressed in quality and quantity of precipitated germs. Most of these are spore formers. The percentage of cocci fluctuates between 10 and 20 per cent.

There are only a few pathogenic staphylococci, most of them are white and yellow pigment formers. Mold fungi seemed to show such a strong dependence on relative humidity that their percentage at relative humidities above 90% may rise to 50 to 80 volume parts of the total germ content, but this assumption must be confirmed by further tests. Ray fungi are also seen frequently. Their percentage of the total germ content amounts to only a few per cent.

Figure 3 shows the germ content of the open air during a few weeks in September 1952. We shall try in the following to coordinate the measured germ concentrations with the air masses and their changes, at the same time we shall consider the daily conditions. The flow of polar air entering Central Europe on the 4th of September continues during the next two days in which connection Greenlandic polar air penetrates as far as the Mediterranean. It becomes quiet only on the following day, the 6th of September. On this day the germ concentrations fall somewhat in comparison to the preceding days. But now stagnating air masses slowly absorb dust and germs from the ground (c.f. 7th of September). In addition, a weak northeasterly flow starting in the night hours of the 8th of September, which is restricted primarily to the upper reaches, pushes continental air masses, partly of sub-tropical origin, above these surface masses of cold air, leaving to warm, rising processes, partly with stormy manifestations. This leads to a vigorous rise in germ concentration to values that are doubled (c.f. 8th of September). This is quite significant since it occurs in spite of the washing effect of the extensive percipitation which undoubtedly is quite effective. The author therefore favors the concept that it is precisely this rain which was formed in the rising warmer and more humid PC and C air which increased the germ content of the cold air situated beneath it. Undoubtedly these so-called giant nuclei (1), being mixed nuclei, also contain germs. These are introduced to the ground air by the process of percipitation.

On September 9 the germ content of the open air abates quickly due to rain, quiet winds and extensive high fog, showing the lowest values of the month.

The flat disturbances which move across Western Europe southwards during the next few days apparently had no influence on the air masses at the observation point. On the other hand, PC-air-advection which takes part in all altitudes becomes more noticable and the barometric distributions of these days support this assumption. The process of aging in air masses is another factor. At any rate, the germ concentrations on the 12th day of September again show higher average values in spite of the rainy weather.

In the following days, under the rising influence of irradient weather and continued advection of originally polar continental air masses, weather conditions favor a rise in germ concentration, promoted also by aging. The marked scattering is caused by the daily conditions. They show the change between the fog and high fog layers dominating the morning which press dust and organisms to the ground and the convection penetrating to high elevations in the afternoon due to almost unimpeded radiation of sunlight (i.e. on the 16th of September).

The decrease in germ content noticed on the following days, the 17th thru the 20 th of September, may be due to invasion of fresh P and PN air which takes place in individual stages. Corresponding to their routes of movement which leads them predominantly across ocean areas, these air masses have had little opportunity to absorb germs from the ground. In addition, temperature conditions represent another factor that inhibits growth in all P and PN air masses. On the 22nd of September, the concentration values rise temporarily par allel to a rise in temperature and humidity content. On these days and the following, of which the 25th is particularly noteworthy, due to its high germ concentration, an analysis of air masses meets with considerable difficulty. In this flow which approaches almost entirely from the west, it is very difficult to differentiate between the original portion of sub-tropical and polar air. We may assume also that, as already indicated above, sub-tropical air masses have better living conditions than the polar ones at comparatively higher values of temperature and humidity. For this reason, the germ concentrations must be subject to greater fluctuations corresponding to the origin of the air masses.

Although an attempt has been made in this study to correlate bacterial concentrations of the air with changes in air masses, the author realizes fully that this only postulates a hypothesis, the proof of which still requires a large number of measurements. The author also believes that possible specific germ content of certain air masses may be assigned only seasonally due to the change in temperature and humidity conditions in the course of the year.

In addition to relations between germ content and air mass, radiation conditions, and absolute and relative humidity, other inquiries seem indicated which may be explained only by relationships published by H. Bortels. However, the author still lacks statistical proof in the form of numerous results.

The bio-meteorologist must limit himself ot his own scientific field in the treatment of the present problems by leaving all pertinent bacteriological work and evaluation to experienced specialists.

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