Measurements of small ions in indoor air

The relevance of the small ion concentration in indoor air on the quality of our indoor climate is undeniable. In this article, various influencing factors on the ion concentration in indoor air will be shown.

1. Ions

The term ions refers to electrically charged particles. Depending on the dominant polarity of the elementary charges, a distinction is made between **negative** ions, which have an excess of electrons, and **positive** ions, in which fewer electrons than protons are present.

2. Small ions

Depending on the mass of an ion and the related 'mobility', a further distinction is made between small ions with a boundary mobility exceeding 1 cm^2/Vs and large ions with a lower boundary mobility.

3. Formation

Ions are formed when energy-rich particles or ionising undulatory radiation causes one or multiple electrons to detach from a neutral molecule or atom. These can then, in turn, accumulate on other particles and thus form new ions. Causes of **natural** air ions in the open air include natural radioactivity, lightning strokes in the atmosphere, water spraying etc. It is even possible to generate air ions **artificially** with 'open flames', spraying water, high voltage, ionisers and radioactive preparations (Alpha nuclides).

4. Effect of air ions

In addition to the biological irritative effect, however, an air-cleaning effect is also described: Due to the electrical force of attraction which comes from the electrical charge, other particles (dust, viruses, bacteria) attach themselves to ions. This increases their mass and causes the particles to sink (to sediment) more quickly to the ground.

5. Measurement method

The ion concentration in the air is measured with **ionometers**. These measurement devices usually contain an external tube electrode in which an additional, smaller tube electrode is insulated and a fan. DC voltage is applied to both electrodes and hence an electrical DC field is generated between both tube electrodes. The preselection of the polarity of the DC voltage is defined by the polarity of the ions to be measured. The fan continually sucks air with a defined volume flow through the electrodes. The electrical DC field steers the ions into the airflow to the internal electrode. The current flowing there during the neutralisation of ions registers a measurable drop in voltage with a high impedance series resistance (100 GOhm). The low current, small pA (10^{-13}A) imposes considerable demands on the measuring amplifier in terms of input resistance, temperature compensation and interference withstanding voltage. The geometry of the electrodes (distance, length), the field strength and the air volume flow are coordinated so that small ions (with higher mobility) can also reach the internal tube electrode during the retention time in the electrical field.

6. Air ions concentrations

In outside air, depending on the weather and location (country/city) a concentration of 200 to 800 ions/cm^3 of positive and negative small ions is measured. These values may be exceeded in coastal areas, at waterfalls or areas with high radon concentrations. The ratio of negative to positive ions varies here from 1:1 to 3:2. The **distribution** of air ions in the air is **non-uniform**.

In **indoor areas**, the **same** ion concentrations as in the surrounding **outside air** should theoretically be recorded, provided no artificial ion sources, as described under 3, are present!

7. Factors

In practice, the reality is often different. Indoor areas often have concentrations that are measurably different from those of outside air. The reasons for this for **low** concentrations are:

- **electrostatic fields** exert forces of attraction on the ions and hence reduce the ion concentration within the electrical field.
- **dusts** and **particles** also reduce the concentration of air ions.

However, it is also possible to measure an **increased** concentration of air ions in indoor air in the following situations:

- **Visible artificial** ion sources such as open flame, fountains etc. are indoors.
- Ionising radiation, caused by **radon gas** (terrestrial or related to building materials) increases the concentration. Under these circumstances, values exceeding 3000 air ions/cm^3 have already been recorded whereas the value outside was 600 ions/cm^3.

8. Electrostatic fields

Today therefore, this is what a 'modern' interior looks like: On the ground is electrostatically chargeable carpet and plastic materials, on the walls are foamed vinyl wallpaper and the

ceilings covered with plastic or polystyrene panels. And within the space, yet more: tables and CD stands made of plastic and plexi, cushions and curtains made of synthetic fibres. Why is a warning included for computer monitors against static electricity when virtually all TV screens have even higher measurable levels of static electricity? The influence of the electrostatic field on the ion concentration is shown in diagram 1. Already 5 minutes after switching on, the ion concentration 2 m in front of the picture tube has dropped from the initial level of 500 ions/cm³ to around 150 ions/cm³. If spaces with electrostatic fields are ventilated, further ions enter the space. These are then directly influenced and deflected by the electrical field.

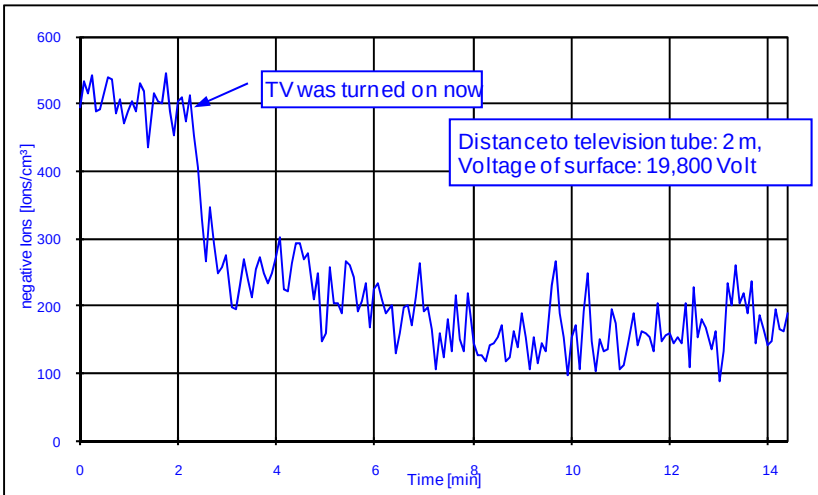

Diagram 1: Reduction after switching on a TV

9. Smoke and dust

The influence of smoke on the ion concentration is visible in diagram 2 during the burning, - or rather 'smoking' – of a joss stick. After 13 minutes, the ion concentration had dropped from 500 ions/cm³ to 100 ions/cm³. The effect with cigarette smoke is the same. Following the measurement, only intensive ventilation of the room made it possible to regain the original ion concentration.

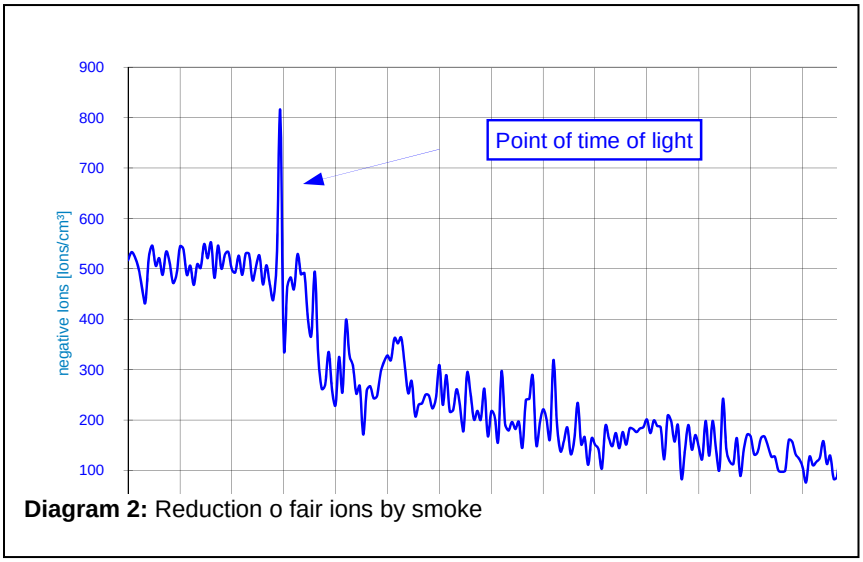

Diagram 2: Reduction o fair ions by smoke

10. Ionising radiation

The radioactive noble gas radon has an ionising effect, which leads to an increase in the ion concentration in indoor air. In diagram 3, the increase in ion concentration over time is shown in an unventilated cellar room. The radioactive gamma radiation was recorded at the start and end of the measurement process with the NaJ scintillation detector. Whereas the showed an increase in the ion concentration after 10 hours of measurement time ex-

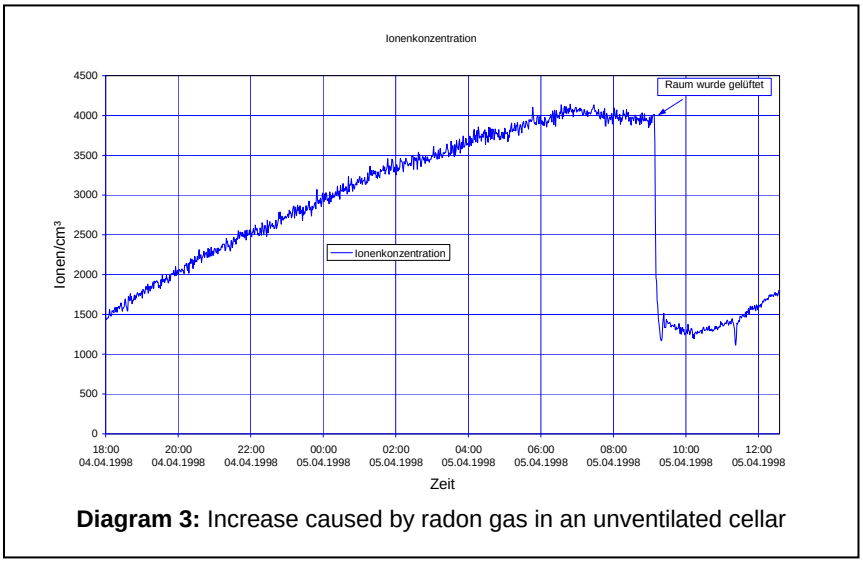

Diagram 3: Increase caused by radon gas in an unventilated cellar

ceeding 2000 ions/cm³, the scintillation counter showed no more than a 'half' impulse.
The effect of a poke ventilation is also visible. After 9 minutes, 'normal' ion concentrations had already been attained. The area data: Volume: 41 m³, window opening during the air phase: 1.2 m², the measuring arrangement was positioned in the middle of the room.

11. Conclusion

The prerequisites for a healthy indoor climate are ion concentrations of more or less equivalent size in the indoor air and outdoor air. Lower concentrations signal 'contamination' in the form of electrical DC fields or smoke. However, substantial increases may be attributable to ionising radiation (radon gas).
An artificial increase in the ion concentration should be considered as a therapeutic application.

12. Literature

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