

Working report
Research project ION Scale Buster®

01.09.- 31.10.2002

Dr. T. Rieling, Prof. Dr. G. Graf

Faculty of Bio-sciences
University Rostock
Albert-Einstein Strasse 23
18051 Rostock

UNIVERSITY ROSTOCK



UNIVERSITÄT ROSTOCK

Introduction

The ION Scale Buster® from ION Devices Deutschland GmbH, Düsseldorf, has been used for approximately a decade in industrial and private water treatment. According to company data, the equipment's principle of action is mainly based on the electro-galvanic principle. The core of the ION Scale Buster® is an extremely pure zinc sacrificial anode which is located between two PTFE swirler bodies and is surrounded by a water stream. The conducting connection of the brass mantle with the zinc sacrificial anode creates a conducting element when filled with water. The release of zinc ions, which is an effect of this, is supposed to promote the agglomeration of water contents. ION Devices Deutschland GmbH regards this agglomeration of dissolved water contents as a competitive reaction to the calcification of pipe walls. Ions which crystallise in the flowing water cannot then settle on the pipe walls and are removed from the pipeline system together with the out flowing water.

The context of the research project by ION Devices Deutschland GmbH together with the University Rostock was the analysis of mineral precipitations through the use of a commercially available ION Scale Buster® in pipeline systems with water flow. The focus of the research was the quantitative recording of the particle size spectrum and evidence of the postulated changes of the particle count and size. The research was accompanied by various chemical potable water analyses by ION Devices Deutschland GmbH.

Material and Methods

The full range of particle tests were conducted in the faculty of Bio-sciences of the University Rostock, department of marine biology, in an experimental test set-up supplied by ION. The test set-up comprised a commercially available ION Scale Buster®, through which water circulated by means of an electric pump in a circulation system made of commercially available drinking water installation components. For the execution of reference trials, the ION Scale Buster® was replaced with a copper pipe. The trials covered combined tests with two different waters (drinking water Rostock and de-ionised water), each of which was carried out with and without ION Scale Buster® treatment (Table 1). Each trial was repeated in parallel, to prove reproduceable potential effects.

Table 1: Experimental arrangements

Zero sample for sedimentation chamber	2 x de-ionised water
Arrangement 1 (particle background in Rostock's drinking water)	2 x drinking water
Arrangement 2 (test related release of particles) Arrangement 3 (control test with drinking water)	2 x de-ionised water with 15 minutes ION Scale Buster® treatment 2 x drinking water with 15 minutes treatment in the test set-up. The ION Scale Buster® was replaced with a copper pipe.
Arrangement 4 (ION Scale Buster® treatment)	2 x drinking water with 15 minutes ION Scale Buster® treatment

To increase the measuring accuracy, 3 sedimentation chambers set up in parallel were inversely microscopized for each arrangement and the particles documented in digital photographs in randomly selected image sections. The evaluation of the particle count and the measuring of the particle sizes was done with the help of a computer with the image processing software analySIS from Soft Imaging System GmbH. An inverse microscope from Olympus (IX 70) was used for the microscopic analysis. A total of 10 digital photos were taken from each sedimentation chamber and analysed. Depending on the particle density, up to 50 particles were counted and measured for each photo.

Furthermore different chemical water parameters (pH, CH⁰d, GH⁰d, KS1,4, Cr, SO₄²⁻, NO₅⁻, Cu²⁺, Zn²⁺) were analysed before and after the test runs by ION Devices Deutschland GmbH own laboratory. The sum parameters pH-value and conductivity were determined with a combination instrument from Hanna Instruments (glass electrode and conductivity probe). The other water parameters were determined photometrically (LASA 100) with application of the corresponding test filter vessels according to Dr. Lange.

Results and discussion

After the installation of the test set-up and various cleaning and trial runs, 8 tests (arrangements 1-4 x 2 parallels) were conducted. As small irregularities in the chamber base (glass faults, microscopic scratches) can influence the definite count of particles through an automatic image analysis, additional image analytical tests of the sedimentation chamber bases were carried out to exclude a falsification of the results through unavoidable material faults of the optical glasses (zero test). An automatic recognition and measuring of the particles could not be realized due to the heterogeneous contra-structure of the sedimented particles. The use of various computer routines (contrast amplification/ reduction, information reduction through 8-bit reduction and subsequent pixel analysis, morphological filters) also did not provide particle-specific properties which could be used to conduct the automatic recognition of the particles. Small quantities of bacteria also proved to be a hindrance, as they could not automatically be subtracted from the particle images. A manual, computer supported measurement of the particles was therefore conducted. The manual approach proved time consuming, but at the same time much more selective for the separation of biological structures and chemical agglomerates.

The first inspection of the digital photographs already showed clear differences between the test arrangements. Figs. 1 a-d clearly show that, after the experimental flowthrough, the particle count in the treated water clearly rose when compared with that in the untreated water. The visual impression was confirmed after determination of the particle concentration for both test runs. After deduction of the chamber specific zero value, particle concentrations of approx. $47,000 - 101,000 \text{ ml}^{-1}$ were calculated for the non-treated water sample (Rostock's drinking water). After treatment of the water in the experimental system with the ION Scale Buster®, the mean particle count rose by the factor 15 – 68 to values of $1,308,085 - 1,717,540 \text{ ml}^{-1}$ in the first of the two test runs. A potential release of particles from the installed technical components (e.g. pump wear) could be excluded in the first test run due to the low particle count in the test arrangement “de-ionised water with ION Scale Buster® treatment” (Fig. 2 a). Besides the found increase of particle concentration in the test arrangement treated with ION Scale Buster®, the control arrangement (ION Scale Buster® replaced by a copper pipe) also showed an increase of the particle count, which was however clearly less marked than in the arrangement with the executed ION Scale Buster® treatment. This particle formation in the control arrangement can possibly be traced back to a temperature dependent re-crystallization process in the experimental arrangement (BIRKEN pers. Mitt?). During the test run, the high pump capacity led to a temperature increase by around $4-5^\circ\text{C}$, where the subsequent cooling could have led to the increased precipitation rate in the arrangements. Furthermore, it cannot be excluded, not even under the cleanest of laboratory conditions, that crystallization seeds (dust particles, bacteria) were introduced into the system during the treatment and transfer of the drinking water sample into the circulatory system. When evaluating the results, it must however be taken into consideration that these effects had the same influence in the same measure on the control arrangement and the experimental arrangement with the ION Scale Buster® treatment. Despite the relatively high particle background in the control version, the effect of the

ION Scale Buster® became evident in a mean increase of the particle concentration by the factor 2.2 in the test run 1.

The effect of the ION Scale Buster® treatment in the particle concentration was able to be reproduced in the second test run. Here too, there was a clear particle formation after the introduction of the drinking water sample into the experimental system. In the second runthrough, the particle concentration in the arrangement with ION Scale Buster® treatment increased by the factor 1.6. If one however looks at the absolute value of the total particle count, it became evident that a clearly lower number of particles were found in comparison with the first test run. It is possible that this lower particle concentration is connected with the overall lower ion concentration in the drinking water used. Due to the source of Rostock's drinking water (filtrate from the banks of the Warnow), a certain natural variability within the natural ion concentrations seems credible, so that a lower ion concentration would then show up in the lower particle formation rate. As there are currently no data available on the water chemistry of the second test run, this question can only be answered at a later date.

- a) Test arrangement 1 (drinking water without ION Scale Buster® treatment)
- b) Test arrangement 4 (drinking water with ION Scale Buster® treatment)
- c) Zero test of sedimentation chamber (de-ionised water without ION Scale Buster® treatment)
- d) Test arrangement 2 (de-ionised water with ION Scale Buster® treatment)

Fig. 1 a – d): Microscopic photos from the indicated experimental arrangements

(Please see original)



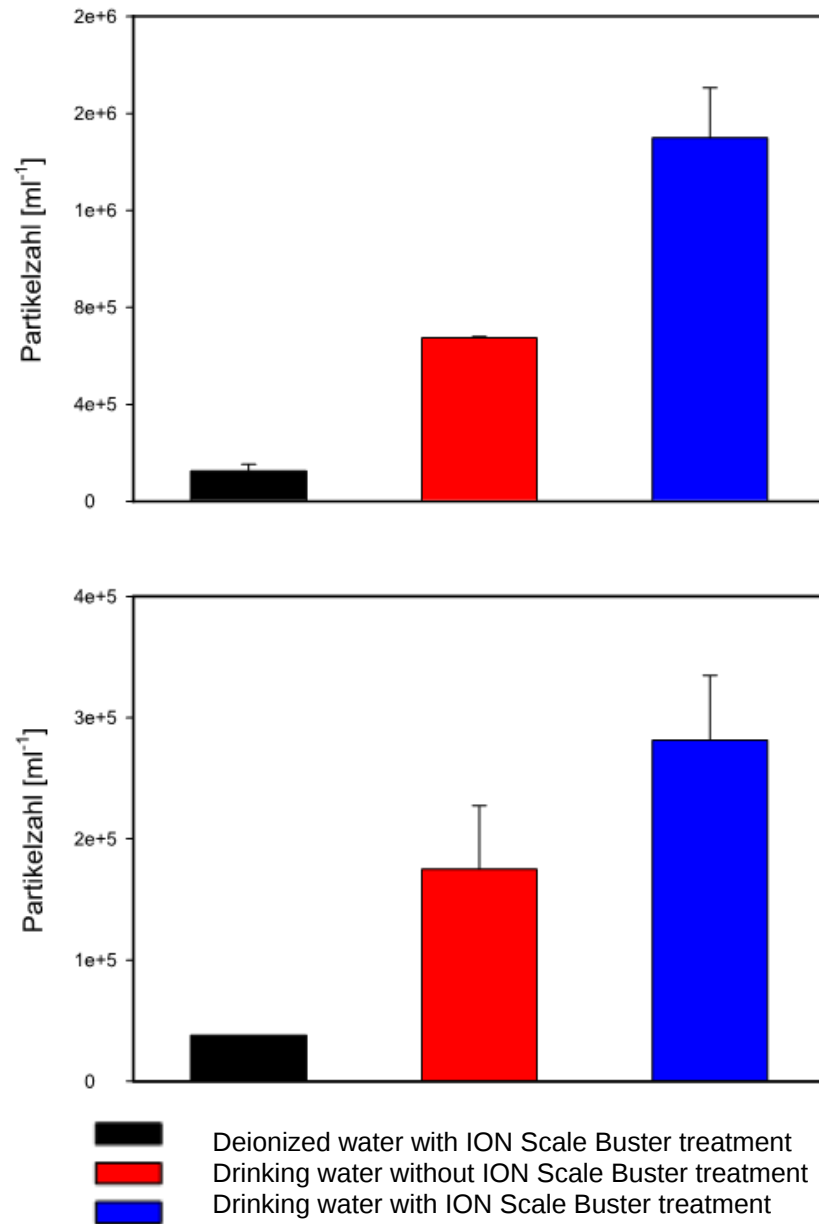


Fig. 2: Number [ml⁻¹] of particles from the test runs 1 and 2, as well as standard deviation from three sedimentation chambers set up in parallel and counted

The postulated effect of the shifting of the particle sizes to higher size classes through the ION Scale Buster® became evident in the comparison of the size spectra of the particles from the control arrangement and experimental ION Scale Buster® treatment:

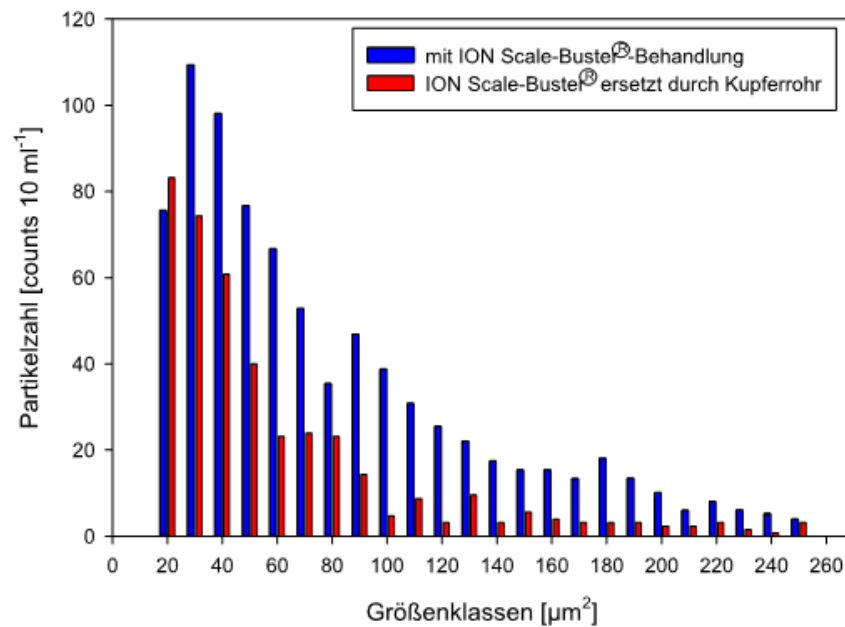
Fig. 3 shows the assignment of all counted and measured particles to different size classes in the range of $10 - 250 \mu\text{m}^2$, normed to a volume of 10 ml. In both test arrangements an exponential decrease of particle surface from the smaller to the larger size classes could be proven. The highest ratio of particles in the total particle count was therefore found in the two arrangements in the size classes below $50 \mu\text{m}^2$. However, it was also shown that the relative increase of the particle count in the samples treated with ION Scale Buster® in the higher size classes was more pronounced. In the mean of the strongly represented classes up to $50 \mu\text{m}^2$ it came to an increase of the particle concentration by the factor 1.5. In the subsequent classes up to $250 \mu\text{m}^2$, the mean however showed a far more distinct increase by the factor 3.9. This also showed when observing the percentage distribution of the particle abundances. Fig. four shows the percentage shares of the particle size classes for the sectors $10 - 50$, $50 - 100$, $100 - 150$, $150 - 200$ and $200 - 250 \mu\text{m}^2$. As the smaller particles (in the image analysis) could no longer be differentiated biologically or minerally, without the use of furthergoing colouring techniques, a threshold value of $10 \mu\text{m}^2$ was set for the evaluation of the particle size spectrum, smaller particles were not taken into consideration for the evaluation. During the comparisons of the size class spectra it became evident that the use of the ION Scale Buster® led to a displacement of the relative significance of individual size classes. While 62% of the particles were to be assigned to the smallest size classes $10 - 50 \mu\text{m}^2$ in the arrangement without ION Scale Buster® treatment, the number of the small particles in the arrangement with ION Scale Buster® treatment sank to 44 %. Contrary to this, the ratio of particles in the next higher size class ($50 - 100 \mu\text{m}^2$) rose from 21 to 30% in the treated arrangement. In the next higher size classes up to $250 \mu\text{m}^2$, a significant increase of the percentage ratios could also be proven, which can be interpreted as a growth of the crystalline particles up to $250 \mu\text{m}^2$.

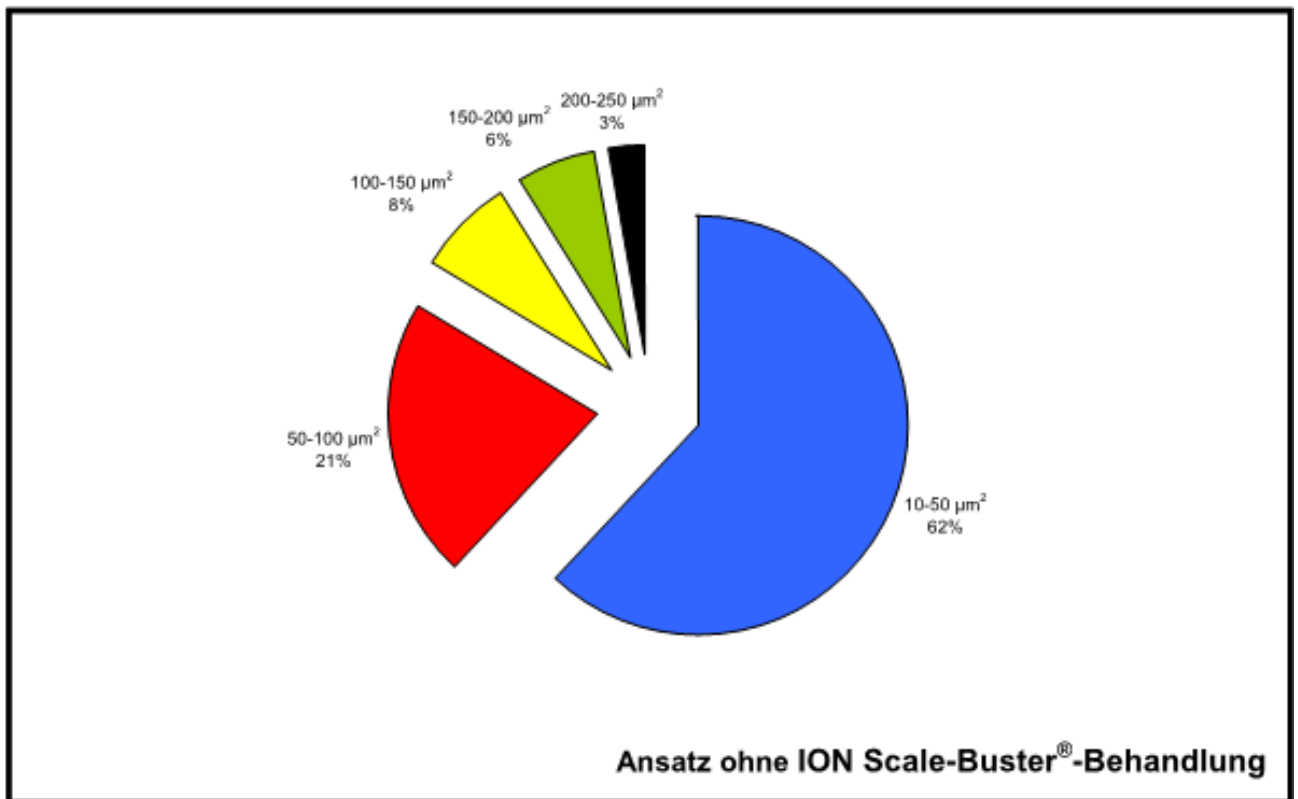
With ION Scale Buster® treatment
 ION Scale Buster® replaced by copper pipe

Particle count (ml) Size classes [μm^2]

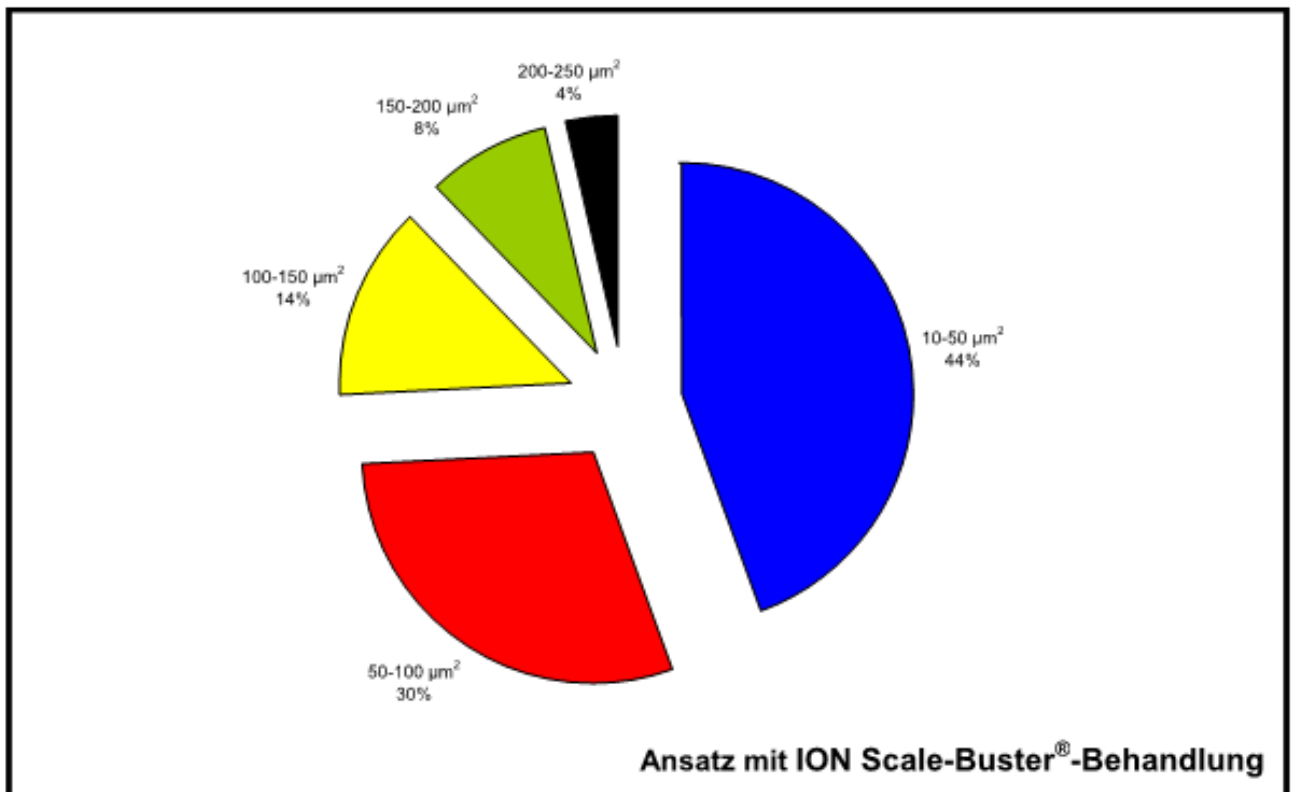
Fig. 3: Total number of all counted and measured particles from both test runs for size classes from $10 \mu\text{m}^2$ to $250 \mu\text{m}^2$ for the test arrangement with ION Scale Buster® treatment and without ION Scale Buster® treatment.

(Please see original)





Test arrangement without ION Scale Buster treatment



Test arrangement with ION Scale Buster treatment

Fig. 4: Percentage distribution of the counted and measured particles (counts / 10 ml) from both test runs with size classes up to 250 micron for the test arrangement with ION Scale Buster treatment and without ION Scale Buster treatment

Water analysis

The parameters summarised in Table 2 were determined to characterise Rostocks' drinking water used in the test arrangements.

Table 2: Chemical water parameters before and after treatment with the ION Scale Buster® (ISB®), as well as chemical water parameters before and after the control test "ION Scale Buster® replaced by copper pipe."

Parameter	De-ion H ₂ O with (ISB®) treatment	Drinking water before (ISB®) treatments	Drinking water after (ISB®) treatment	Drinking water before copper pipe	Drinking water after copper pipe
PH	7.2	7.7	7.7	8.0	8.1
Conductivity [$\mu\text{S cm}^{-1}$]	13	690	623	787	691
C [H^0d]	1.6492	10.4	8.4	9.2	9.5
G [H^0d]	0.048	17.7	14.8	15.8	15.5
KS _{1,4} [mmol l^{-1}]	0.589	3.7	3.0	3.3	3.4
Cl [mg l^{-1}]	n.d.	65.1	53.8	85.6	69.8
SO ₄ ²⁻ [mg l^{-1}]	n.d.	86.7	68.3	63.1	74.7
NO ₃ [mg l^{-1}]	n.d.	1.06	0.43	3.97	2.15
Cu ²⁺ [mg l^{-1}]	n.d.	1.42	0.13	0.41	0.58
Zn ²⁺ [mg l^{-1}]	0.19	3.00	3.08	3.77	2.89

When comparing the samples before and after the drinking water treatment, the pH values showed no difference, as was expected. After ION Scale Buster® treatment, the comparison of the conductivity as sum parameters for dissolved salts however resulted in a reduction of the conductivity by around $70 \mu\text{S cm}^{-1}$, which may possibly be traced back to a reduction of the concentrations of dissolved ions. This tendency continued in the sum parameters for carbonate and total hardness and was also detectable in the comparison of the chloride, sulphate and nitrate concentrations. The particle formation induced by the experimental treatment and the use of the ION Scale Buster®, as COETZEE et. al. could also prove in 1996 after the introduction of zinc ions into the drinking water, therefore led to the reduction of the concentration of the measured free ions. In this connection the reduction of copper ion concentration in the arrangement with the ION Scale Buster® treatment, which was reduced by more than 90% of the originally present concentration is conspicuous. This result follows the electro galvanic effect of the zinc sacrificial anode as zinc is oxidised in the course of the ION Scale Buster® treatment and the copper ions are reduced to metallic copper which is no longer recorded by photometric means. Corresponding with the reduced copper ion concentrations, higher zinc concentrations

should be detectable in appropriate proportions after the treatment. In reality, the increase of the zinc concentration was however insignificant. It must however be taken into considerations that only the dissolved zinc ions are proven with the currently used photometric analysis with commercial tests (BIRKEN, pers. Mitt). The crystalline bound zinc is not accessible to the available analysis. The result therefore supports the statement that zinc ions are to a major degree involved in the particle formation and growth

The found reduction of the copper concentration through the installations of the ION Scale Buster® seems of interest for the further investigation. Copper belongs to the biologically essential metals for human nutrition. The WHO (World Health Organization) for example, recommends a daily intake of 1-2 mg d⁻¹ for infants and children as well as 2-4 mg d⁻¹ for adults (WHO 1996, www.who.int/water_sanitation_health/GDWO/Chemicals/copperfull.htm). Increased copper concentrations in the drinking water can however develop biologically toxic effects. Chronic copper diseases within early childhood development, in particular, can present problems. The standard value demanded by the drinking water order (1991) is therefore 3 mg l⁻¹. Copper pipelines of household installations as they are used, for example, in about 60-70% of all households in the old federal states (former West Germany) can lead to copper contents of several mg/l in the drinking water, due to corrosion processes (WAGNER et al. 1996). This could be a further area of use for the ION Scale Buster® in the sense of an improvement of the domestic drinking water quality. A further going analysis of this effect would therefore offer itself as logical.

The observation of the chemical parameters of the control arrangement showed that an effect on the water chemistry after the experimental run through also took place through installation of the copper pipe. This concerned in particular the parameter of conductivity, as well as the concentration of the anions. While the conductivity decreased by 76 µS cm⁻¹, the concentration of sulphates increased by about 10 mg l⁻¹. The concentration of chloride and nitrate however decreased by 15.8, resp. 1.8 mg l⁻¹. These non-uniform trends of reduction and increase of the various ions documented that complex chemical conversions also occur in the control system, which cannot be fully recreated with the currently used analytic methods. The principal principle of effect of the ION Scale Buster® however became obvious in the degree of hardness comparison. While the treatment with the ION Scale Buster® led to a clear reduction of the dissolved earth alkaline metals, their concentration in the control arrangement with copper pipe remained nearly constant. With this background, a further detailing of the analysis should be conducted, the focus should be placed on the specific analysis of particular, resp. bound hardness formers.

Summary

The object of the research conducted at the University Rostock was a control of the statement about the effect of the ION Scale Buster® on particle formation postulated by ION Devices Deutschland GmbH. Rostock's drinking water and de-ionised water were subjected to a treatment by a commercially available ION Scale Buster® in a model circulation system. In control tests, the ION Scale Buster® was replaced by a simple copper pipe. Particle samples were sedimented out from the water samples and measured by image analysis.

It could be shown that the ION Scale Buster® induces an increase of the particle concentrations by the factor 1.6 to 2.2 in the model cycle. At the same time, an increase of the particle size from $10\text{ }\mu\text{m}^2$ to $250\text{ }\mu\text{m}^2$ was able to be proven by means of the particle size spectrum.

The photometric analysis of the chemical water parameters showed a general reduction of the salts dissolved in water, which was probably due to the increase of the formed particles. Copper, in particular, showed a clear reduction of the concentrations.

Literature

- WHO (1996): Trace elements in human nutrition and health. Geneva, World Health Organization
- http://www.who.int/water_sanitation_health/GDWO/Chemicals/copperull.htm
- Mortimer, Charles E. (1987): Chemie, 5th edition, Georg Thieme Verlag Stuttgart, New York pg. 608 annex
- D. Wagner, W.R. Fischer, H.H. Paris, O. von Franqué (1996): Microbiological Influenced Corrosion in Copper Potable Water Installations. In Microbially Influenced Corrosion of Metals, EDS. E. Heitz, H.-C. Flemming, W. Sand, Springer Verlag, Berlin 1996, pg. 259
- Coetzee, P.P., Yacoby, M., Howell, S. (1996): The role of zinc in magnetic and other physical water treatment methods for the prevention of scale. WATER SA, 22 (4): 319-326

Annex

- CD with raw data
- CD with particle photos