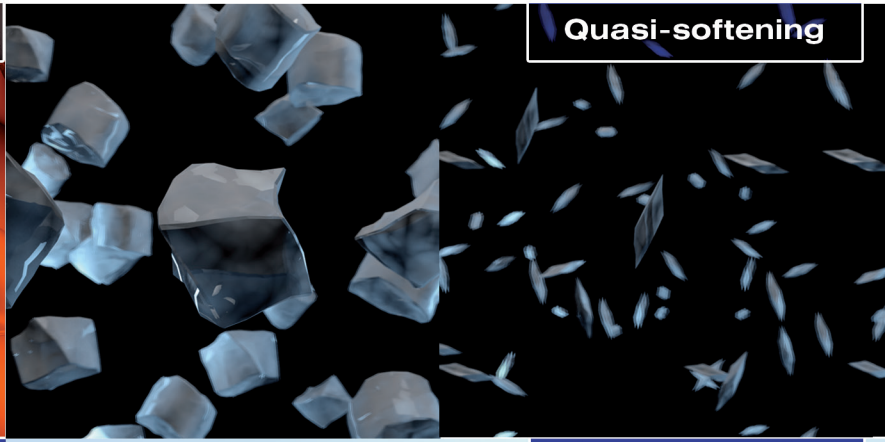
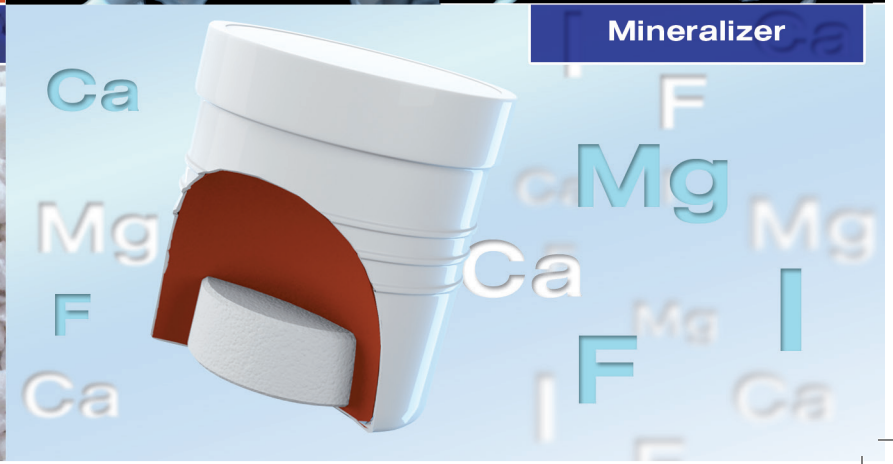
KNOW HOW

Geyser water treatment technology

GEYSER® water filters





ARAGON / ARAGON 2

Polymers with a space globular structure (SGS-polymers) were first synthesized in the USSR as the type of ion-exchange resins in the middle of 20th century.

Today only Geyser has a serial production technology of this material. SGS-polymers are radically new material combining three types of filtration: mechanical, sorption, and ion-change filtration. None of known sorption materials can remove such a wide range of chemical compounds as SGS-polymers do.

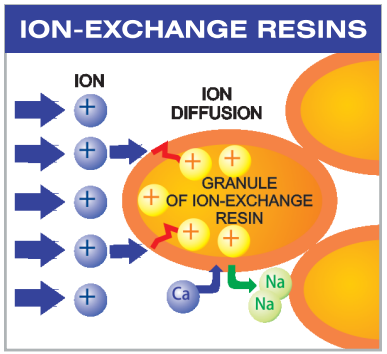
SGS-polymers are macromolecular compounds which can be prepared from various monomers, e.g. resorcin, pyrocatechol, hydroquinone, melamine, carbamide, etc.

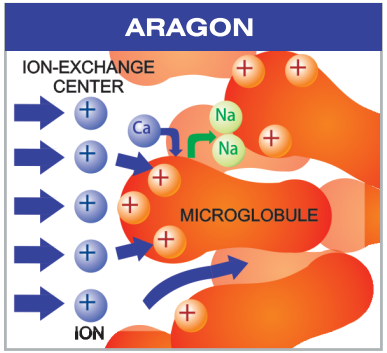
Microglobules, i.e. long polymer chains convoluted in coil, are formed in the process of synthesis of the SGS-polymers. Being aggregated these microglobules provide porous and still mechanically strong structure.

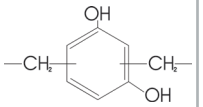
Microglobules have large inner surface (up to 500 m²/g). The surface itself is coated with active groups on which the ion-exchange processes are performed. The removable ions directly interact with a chemically-active polymer surface missing typical for ion-exchange resins stage of granule inward diffusion. As a result the rate of the volumetric filtration of the SGS-polymers is 10-20 times higher compared to common granulated ion-exchange resins. This is a decisive advantage of the SGS-polymers.

The removal of mechanical impurities is mainly performed in surface layers of polymer. The pore size can vary in any range from 0.01 to 3.5 mkm. The required porosity of the material can be obtained by changing the synthesis conditions with an accuracy of no more than 10%.

Currently nearly 30 modifications of the SGS-polymers have been studied and the operation procedures for their production were developed. The materials with both cation- and anion- exchange properties were also synthesized.





Type	Structure	Monomer	Recovered compounds
ARAGON		Resorcin	Heavy metals, chlorine-containing organic compounds

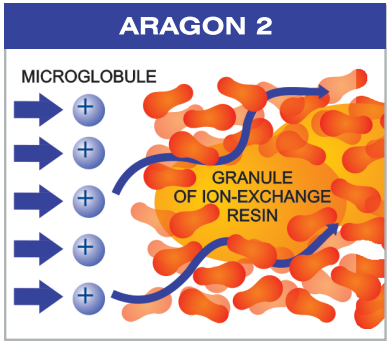
Application field of the SGS-polymers is wide and include purification of:

- Drinking water and hot water
- Juices, vines, sunflower oil
- Technical waters, acids and alkalis
- Waste waters, including oil-contaminated water
- Gases, including exhaust gases

SGS-Polymers in Water Treatment

ARAGON — resorcin-based polymer shows the best results in complex removal of harmful impurities from water. It has successfully passed strict compliance tests to Russian and International standards (NSF) to be used in drinking water purification systems. Dissolved chemical elements (from aluminum to heavy and radioactive metals) and their compounds are removed from water by means of ion-exchange and sorption mechanisms.

ARAGON 2 is a composite material in the form of solid block made from Aragon polymer with a bacteriostatic additive of silver and granules of ion-exchange resin.



Hardness salts, dissolved and colloidal iron, heavy metals and their compounds are removed due to ion-exchange properties of resin and polymer. Ion-exchange resin increases hardness salts removal resource of ARAGON 2 by 12-15 times compared to ARAGON material.

The ARAGON sorption capacity is comparable with the best brands of activated carbon which provides removal of active chlorine, chlorine-containing compounds, and organic compounds.

The mechanical filtration of all particles with the size larger than the size of the external pores of the material is performed on the surface. The filtration channel has a complex tortuous form with a gradient porosity preventing discharge of filtered impurities into the purified water that often happens during pressure jumps. The number of free channels in the material gradually lowers decreasing the pressure of the purified water*. Aragon-based filtering element can be used repeatedly.

The labyrinth internal structure of ARAGON acts as a barrier for microorganisms. The majority of bacteria and viruses have oblong shape (from 0.5 to 20.0 mkm), that is why they are trapped in the tortuous channels of the material. To suppress the growth of microorganisms absorbed in the polymer, silver is inserted into the material in the form entirely preventing its migration into the purified water.

Quasi-softening is the unique feature of the ARAGON material. The structure of hardness salts is changed in water passing through the filtering material. As a result, no scale is formed in purified water. The water acquires the properties having favorable effect on living organism. More detailed information on effect of quasi-softening will be discussed hereafter.

The material has high mechanical strength with the possibility of mechanical treatment (cylinders, discs, etc.). Compact and efficient filters based on ARAGON material are unified in accordance with main international standards. The ARAGON sorbent was successfully used for water treatment in the regions exposed to contamination after the Chernobyl accident.

* Water pressure drop indicates the necessity of regeneration or replacement of the cartridge.

UNIQUE PROPERTIES OF ARAGON MATERIAL

Traditional methods applied for water softening and scale prevention are ion exchange and reserve osmosis. Both methods remove just excess hardness salts from water. These are reliable but rather expensive methods.

An alternative way to prevent scale formation is to leave hardness salts in water, but to change their structure so that they will not form hard deposits when heated. Scale usually consists of calcium carbonate in the calcite form. However, there is another crystalline modification of calcium carbonate — aragonite. Aggregation and surface adherency capability of aragonite crystals are substantially lower than those of calcite. Aragonite precipitates in the fragile and loose form.

Up to now, magnetic water treatment was the only method using this property of aragonite for scale removal. Treatment of hard water with a Geyser Aragon filter in various geographical regions always revealed the same effect. Even when ion-exchange capacity of filter is exhausted, the water passed through Geyser filter does not form scale and, moreover, washes away the old one.

Surface of heating element after 6 month operation in hard water:

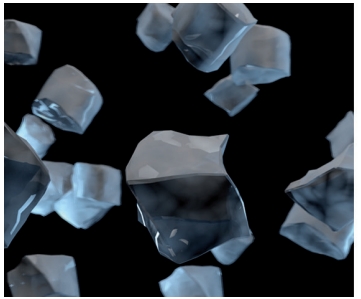
Without Filter

With Geyser Filter

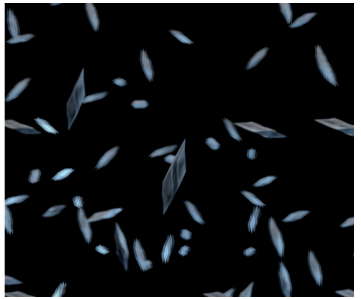
Observed phenomenon, was called “quasi-softening”.

Formation of aragonite structure of hardness salts as a result of water flow through Geyser Aragon filter was confirmed on experimental grounds. Changes in crystalline structure of precipitate and rhombic aragonite crystals are clearly seen through the microscope.

Crystalline structure of precipitate:



Common hard water

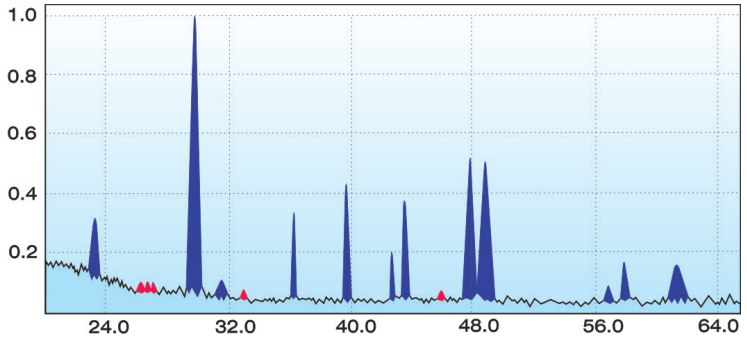


Water treated be Geyser filter

The results of X-ray analysis carried out by National Institute of Mineral Raw Materials of Russian Academy of Sciences, also state that the content of aragonite form of calcium carbonate in water substantially increases after filtration through Aragon.

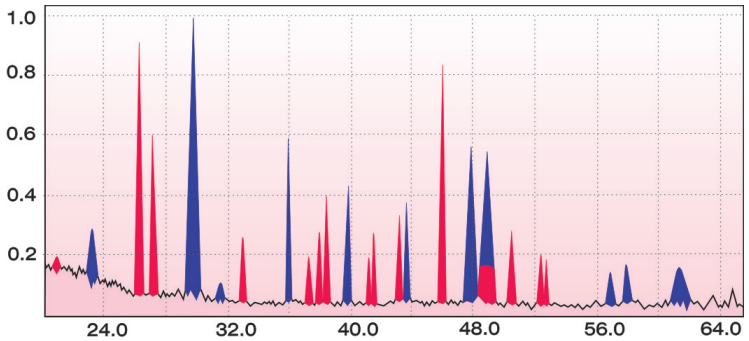
Common hard water

5% aragonite / 95% calcite (spectrum No. 1)



Geyser filtered water

40% aragonite / 60% calcite (spectrum No. 2)



Collaborative studies with Vienna University performed on hard water in Austria and Germany, confirmed the “quasi-softening” effect with accumulation of aragonite and allowed describing the mechanism of this phenomenon.

Let us consider transformations of hardness salts during filtration. Hardness salts exist in aqueous solutions in the form of metastable compositions, called clusters. Aragon material has a porous structure formed by a number of tortuous channels. Constantly increasing pressure resulted from narrowing of the channel produced by cluster passing through the material shifts the chemical equilibrium towards the dissolution of carbon dioxide, which is always present in water.

Chemical activity of ARAGON polymer in combination with its advanced porous structure creates conditions for recrystallization of clusters from calcite into aragonite. On leaving the filtering element, the pressure initially increases to the maximum value with the following sharp decrease. The carbon dioxide is exhaled and it quickly escapes from the water. A similar gas escaping effect is observed when we open a bottle of carbonated drink. The liberation of carbon dioxide slightly increases the pH of water, shifting the equilibrium towards carbonate formation. As the result the solution is supersaturated over calcium carbonates and aragonite nuclei are formed. The aragonite solubility decreases with further heating. Aragonite is known to be less supersaturation-resistant than calcite. Aragonite very rapidly precipitates in the bulk of the solution rather than deposit on the surface, which is of practical importance.

The filtration process of aragonite changes the physical structure of hardness salts into aragonite form without noticeable change in the mineral composition of water.

The “quasi-softening” effect is achieved without any additional equipment being a unique property of filtering material. Considering the fact that aragonite water does not form scale and gradually

dissolves old deposits one can suggest that similar effect of such water can be observed on living organism, dissolving nephroliths (kidney stones). The influence of water filtered through Aragon material on living organisms was studied at the Military Medical Academy (St. Petersburg).

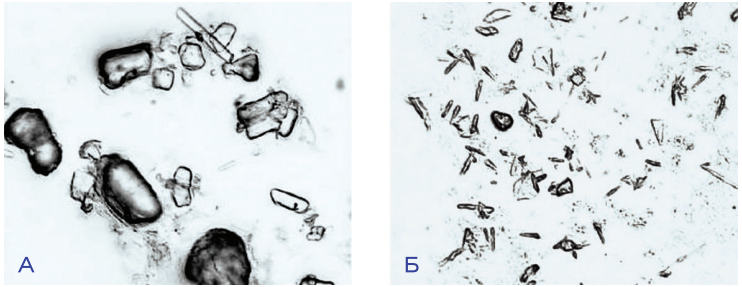
Two blind experiments were conducted on two groups of white rats within the period of 30 days. Animals of the first group were receiving hard tap water, while animals of the second group were receiving the same water but filtered through the Aragon material. Prior to giving the water to the rats of the 2nd group, the filter was operated in hard water for a long time. As the result it was saturated with calcium and magnesium salts and the hardness value of initial and filtered water was almost equal. This allowed factor of chemical change of water composition to be excluded, retracing the influence on rats of "quasi-softening" effect only. The most significant differences between animals of different groups were obtained based on the analysis of urine deposits (see fig).

Urine of animals of the first group contains large crystals capable of forming nephroliths. Moving, these crystals inflict mechanical damage on internal tissues of kidneys and urinary tracts. This hypotheses is confirmed by the presence of proteins and blood in the urine. These micro injuries can contribute to the development of internal infections.

It is safe to say that consumption of the Geyser filtered hard water leads to the decrease of both the size and the number of crystals in urine that provoke stone formation. Such a positive change in the urine composition is possible as the response to increased calcium inflow and calcium is better assimilated by organism being a part of Aragonite.

Aragonite form of hardness salts facilitates calcium assimilability, improves functions of gastrointestinal tract and liver, decreases kidneys loading, and reduces the chances of nephrolith formation.

Water treated with the Geyser filter with Aragon material can be used as a non-medicated prevention of urolithiasis.



Composition of urine precipitate of rats taking tap water (A) and filtered water (B)

ARAGON BIO filtering material for treatment and decontamination of water

Test results of Aragon Bio material in Russia and USA on real hepatitis A virus, noroviruses, rotaviruses and MS2 virus model showed their complete removal up to concentration of 10^8 pc/ml.

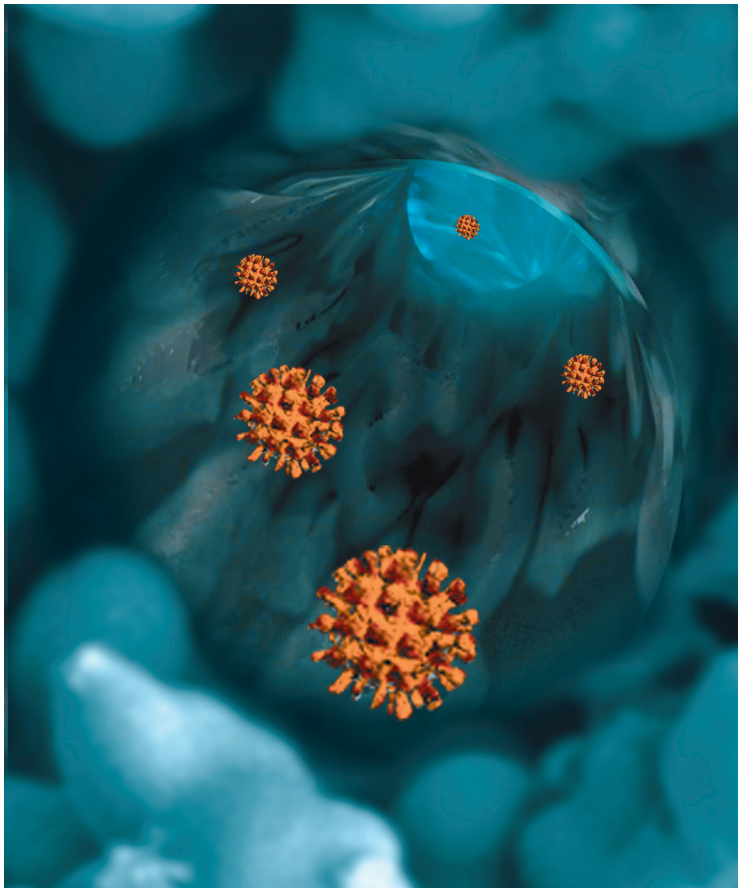
Test results of noroviruses and rotaviruses removal by Aragon Bio cartridge

Concentration, p/l	$1{,}0x10^9$	$1{,}0x10^8$	$1{,}0x10^7$	$1{,}0x10^6$
Before filtration	+	+	+	+
After filtration	+	–	–	–

Measured by PCR method (polymerase chain reaction)
+ viruses found
- no viruses found

The pore size of Aragon Bio cartridge is 0,5 mkm, while the sizes of viruses are about 30-40 nm, i.e. 15 times smaller. If there were no interaction between pores of the material and viruses, then, due to its insignificant size, they would go through pores as easy as insects fly through the window. However, as it was determined, the Aragon pores have an intense surface charge, opposite in sign to the viruses' one. This implies that electric interaction that occurs between Aragon material and viruses is similar to interaction of opposite charges.

The Aragon material has such a structure that the average size of the pore is about 0,5 mkm. Hence the electrical field from globule completely overlaps the internal volume of the pore. Due to the combining of fields of separate globules an electrical field with high tension is formed within the pore. Let us take standard Aragon cartridge as an example. The thickness of its filtering layer is 30 mm. To cross this barrier the virus must pass a twisted chain of about 40 000 charged pores. Who of us haven't licked the battery to check whether

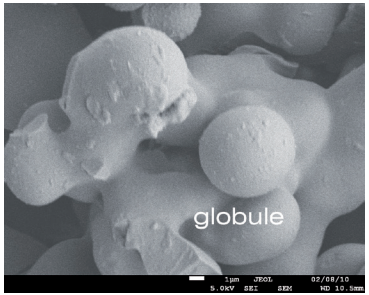


it's fresh or not. Or haven't accidentally touched bare wire? Likewise the viruses, coming through the pores, receive electrical discharges, but 1000 more powerful, that eventually leads to destruction of viral envelope and inactivation of virus itself.

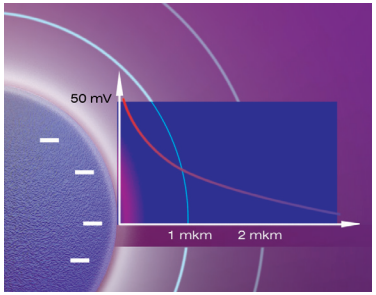
The capacity of Aragon Bio globule for electric interaction is defined by zeta potential. This potential was measured and appeared to be 45 mV, which is much higher than zeta-potential of common spectrum related cation-exchange materials (5mV).

It has been determined that zeta potential of Aragon Bio globules decreases as the size of the pores increases. Efficiency of decontamination of viruses has similar behavior. That is why for guaranteed decontamination of viruses and bacteria Aragon cartridges are manufactured with strictly specified porosity not exceeding 0,5 mkm.

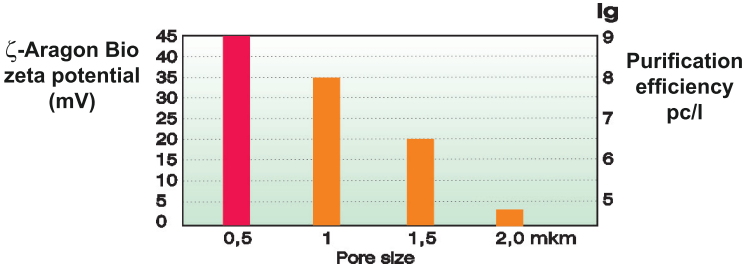
Aragon material structure



Globule electrical field



Test results of measuring of Aragon Bio zeta potential depending on its porosity



Difference of Aragon Bio from Aragon and Aragon 2

- **Monodisperse distribution of pores (0,5 mkm)**

  To achieve required pore size at production of filtering material Monocondensing patented technology is used, ensuring effective water treatment through the whole volume of filtering material within all operation life.

- **Reduced globule size (up to 5 mkm)**

  This allows increasing zeta-potential of Aragon Bio filtering material by means of increasing of inner absorption surface.

- **Biocidal material composition**
- **Metallic silver is applied on the inner surface of the pore**
- **Total quality control of every cartridge at manufacturing**

How dangerous can the high iron and manganese content in water be?

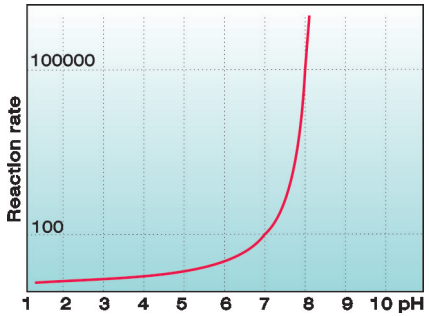
IRON, accumulated in human body, destroys liver, immune system, increases the chance of heart attack.
MANGANESE can cause serious pregnancy problems, increases the risk of allergy, impotency and Parkinson's disease development.

HOW TO TREAT WATER TO REMOVE IRON?

Any source of water (public water supply, water wells) can contain IRON. Such water has yellowish color, taste of rust, and iridescent film on surface.

New multipurpose material for removal of insoluble iron (patents No. 2218984, 2219994) is created based on natural material Dolomite by means of introduction of catalytic additives to it. The principle of removal is based on acceleration of the process of shifting iron into the insoluble form of hydroxide (oxidation) with subsequent plain mechanical filtration. The rate of this process depends greatly on acid intensity of environment (pH level). Increasing the pH by just 1 (e.g. from 7 to 8) results in thousandfold increase of the reaction rate of hydroxide formation. Ferric hydroxide itself facilitates more effective oxidation of soluble iron ("iron removes iron") and absorbs clay, sand and organics. The property of calcite to accelerate oxidation processes also allows it to remove effectively high concentrations of manganese (MPC up to 10).

REACTION RATE - pH GRAPH



All advantages of the filtering material are realized in multistep systems through step-by-step water treatment.

CALCITE Removes iron, manganese, suspension, sludge and sand from water.

ARAGON Mechanical and chemical treatment to remove bacteria and viruses. Correction of pH.

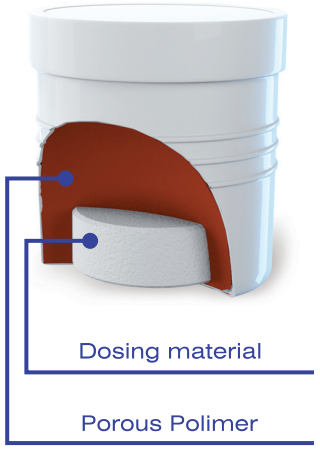
ACTIVATED CARBON Water conditioning, chlorine and organics removal.

The filtering material is made of natural ingredients and unlike imported filling media like "Birm" and "Green Sand" it prevents entry of manganese, so destructive to our health, into potable water and environment.

GEYSER MINERALIZER

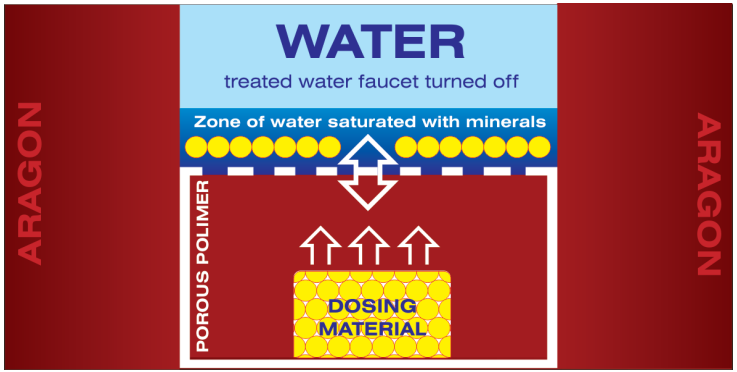
Vitamins and mineral elements play a key role in maintaining vital functions of the human body. Deficiency of these nutrients in our diet may result in health problems and chronic illnesses.

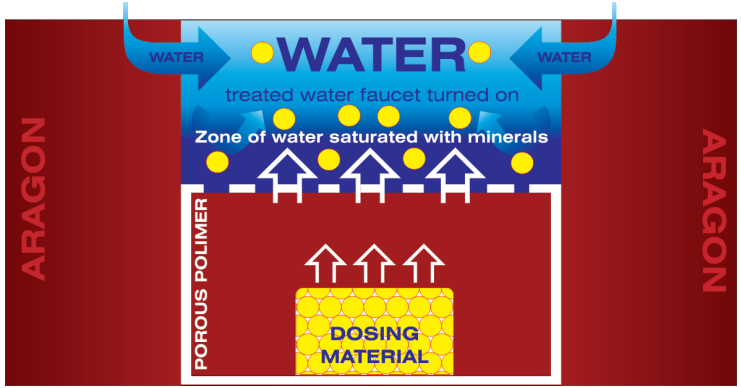
Geyser was the first to develop and patent an innovative compact mineralizer i.e. feeder of mineral elements. This feeder automatically releases minerals into water in necessary concentrations to compensate their deficiency in tap water.



The idea of the above mentioned invention can be described on the simple example. It is well known fact that the cup of tea cannot become tasty until we stir up the sugar. Without it, it will lie on the bottom and only a small water layer right above it will be very sweet – the part of sugar is dissolved in it – because the system is balanced. If we start to stir up the water, we disturb the system gradually dissolving the remained sugar.

The same happens at installing mineralizer into the filter. Water on entering inside the device dissolves dosed material until the equilibrium between the content of corresponding microelements inside the feeder and boundary layer is attained.

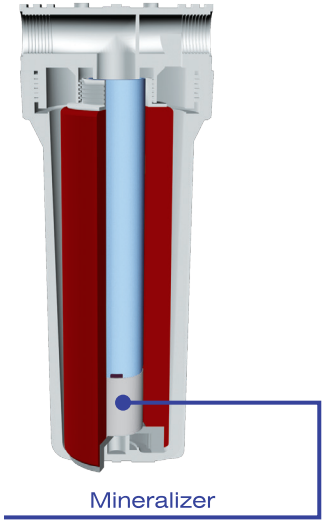




The equilibrium is broken at the beginning of filtration and the water flow washes out minerals from the feeder into the treated water.

The end of filtration returns system back to the initial equilibrium state. The more we turn the faucet on, the stronger the material dissolution is.

In such a way we can dose any beneficent microelements into water.



Mineralizer

At the present day Geyser produces the following feeders:

CALCIUM AND MAGNESIUM are essential for our heart, nervous system and generally for the health.

IODINE deficiency leads to immunity decrease. The recommended daily intake is 0.1-0.15 mg/l. Today about 100 million people in Russia live on territories with deficit of natural iodine.

FLUORIDES serves as biocatalysts of metabolic processes facilitating capturing and accumulation of calcium in the organism and preventing tooth decay. The recommended daily intake is 1.5 mg/l.

Extra Softening

Recent Geyser development for household filters based on the patented technology of hydrogen ions dosage into water.

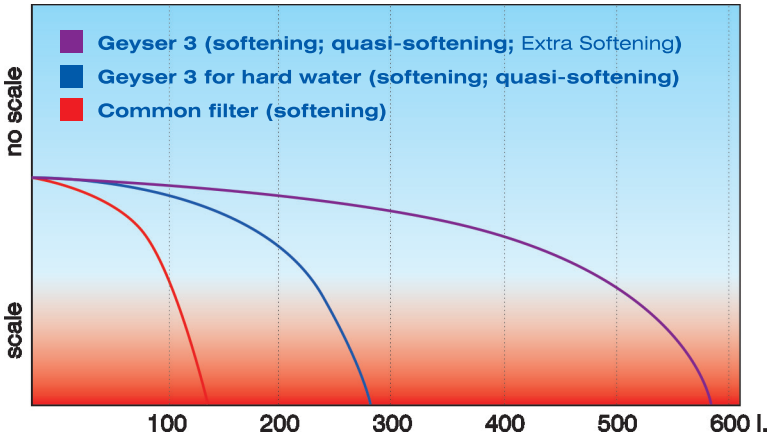
RF Patent No. 2212378

Special feeder based on Aragon material allows pure water to be dosed with required amount of hydrogen ions. It allows decomposition reaction of acid precipitation of calcium carbonate (scale) to be launched on water and carbon dioxide.

$$(HCO_3)^- + H^+ = H_2O + CO_2\uparrow$$

As the result only ion of calcium is left in the water without scale formation.

Scale formation in water



KNOW HOW

Geyser water treatment technology

GEYSER
water filters

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