ADSORPTION OF INORGANIC COMPOUNDS

This article describes the most up-to-date advances in adsorption technology, emphasizing the removal effectiveness of the **AQUASPACE Water Treatment Compound** against recently discovered toxic chemicals in our water supplies and the evident inadequacy of existing water treatment systems. **The AQUASPACE Water Treatment Compound** is the first major advance in years in adsorption technology.

As pollution of our water supplies continues, it becomes increasingly important to find ways of combating it or eliminating its effects. The **AQUASPACE Water Treatment Compound** for the treatment of drinking water offers an economical and effective answer to this serious contemporary issue.

This article serves as an invaluable help for environmental scientists, public health officials, municipal water authorities and environmental protection officials.

It will be equally beneficial to both academic and industrial researchers of water treatment, as well as chemists and engineers involved in the operation, design and evaluation of municipal manufacturers of water treatment systems.

The merits of **AQUASPACE Water Treatment Compound** for the removal of organic compounds in water have been well documented in other AQUASPACE Technical Bulletins, but potential for adsorption of inorganic compounds has only recently been studied. Studies in the field of metallurgy have indicated reasonably good adsorption of most metallic compounds. Therefore, the purpose of this article is to point out the potential for helping attain AWWA (American Water Works Association) goals through adsorption of hazardous contaminants.

Numerous articles have been published relating to risk assessment through exposure to heavy metals such as Lead, Mercury, Chromium, Cadmium, Arsenic, Selenium, Aluminum and Fluoride. They have been determined to be carcinogenic or mutagenic to humans and they substances have infiltrated our water supplies from industrial wastes to lead pipes in delivery systems to even the process of water treatment itself. Many of the above substances have been adsorbed by **AQUASPACE Water Treatment Compound** in one form or another, thus suggesting investigation of their removal potential from water supplies.

In only a few instances have studies been made under conditions likely to exist in a real water supply situation. The metallurgical studies have primarily been conducted in laboratory conditions where the metal to be adsorbed was the only contaminant in the solute utilized for the tests. Principles of adsorption must therefore be considered in an effort to predict the efficiency of removal from consumptive water supplies. An important factor is that it is much more difficult to adsorb low concentrations of any material. On the other hand, it is usually necessary to remove only very small amounts to eliminate any hazard. Generally, metallurgical solutions treated are very strongly acidic, a condition providing a very high degree of solubility. It has frequently been said, "adsorption is a fight against solubility". In other words, better adsorption can be expected when conditions render the compound less soluble. This situation, of course, would prevail if water supplies contained little or no acid.

This defining chemical condition would appear to offret that of concentration in consumptive supplies with the magnitude of each being very difficult to assess. The pH values reached in water softening operations could possibly give even more favorable conditions for adsorption.

POTENTIAL FOR METALS REMOVAL (very good)

Laboratory test results and educated guesses regarding adsorbability have been reported. Some of the metals having high adsorption potential are shown in Table 1.

ANTIMONY (Sb): The effect of antimony on health could be similar to arsenic since it is in the same chemical family. Assessment of toxicity of antimony and its compounds is difficult because of its close association with lead and arsenic. No AWWA goal has been set. Using the **AQUASPACE Water Treatment Compound**, studies showed adsorption of both antimony and arsenic from a copper sulfate, with sulfuric acid concentration usually above 1N. Impurities, such as antimony and arsenic, are present in much lower concentrations. More

recent studies showed that the **AQUASPACE Water Treatment Compound** could pick up as much as 60% of its own weight of antimony from such solutions. Laboratory studies on antimony trichloride in a strong HCl solution showed about 25% loading on the AQUASPACE Water Treatment Compound. Considering the relatively low concentrations involved and lower degree of solubility at high pH value, the **AQUASPACE Water Treatment Compound** should have an excellent potential in water filtration.

ARSENIC (As): Arsenic can cause severe poisoning and it accumulates in the body. A characteristic of arsenic poisoning is the great variety of symptoms it can produce. Since it has been widely used as an insecticide, it is possible that it may reach water supplies and has actually been detected in some areas. The proposed AWWA goal is 50 ppb. As mentioned in the discussion on antimony, arsenic is adsorbed by the **AQUASPACE Water Treatment Compound** from a copper electrolyte solution. Potential in water treatment should be very good, the degree of adsorption depending on the form in which the metal occurs.

Bismuth (Bi): Bismuth may be suspect since it is in the same chemical family as arsenic and antimony. We place bismuth compounds in a slightly toxic category. No AWWA goals have been set. In one industrial application, substantial quantities of bismuth were removed on a bed of the **AQUASPACE Water Treatment Compound**. Potential for removal, therefore, should be rated as very good.

CHROMIUM, HEXAVALENT (Cr6): We report compounds of chromium to be highly toxic and the chromate salts have been associated with cancer of the lungs. AWWA goal has been set at 10 ppb. Laboratory studies have shown the **AQUASPACE Water Treatment Compound** to have very good adsorption, plus the additional ability to reduce hexavalent chromium to the lower valence. Potential for the **AQUASPACE Water Treatment Compound** should, therefore, be rated very good.

LEAD (Pb): Lead is a serious cumulative poison that should be avoided. AWWA goals have been set at 20 ppb. Laboratory studies on solutions of lead nitrate and lead acetate show little adsorption at a pH of 2 but good removal at a pH of 5. Prospect for removal from water at a pH in the range of 7 would be quite good to excellent.

POTENTIAL FOR METALS REMOVAL (good)

Table 2 covers several metals of good adsorption potential.

SILVER (Ag): Silver can cause a grayish pigmentation in various tissues of the body, resulting in discoloration on the skin and mucous membranes and such pigmentation is permanent. The AWWA has set a goal of 50 ppb. Laboratory studies on a silver nitrate solution showed the **AQUASPACE Water Treatment Compound** could pick up 9% of its own weight at a pH of 2.1 and 12.5% at a pH of 5.4. It is retained due to reduction to free metal on the **AQUASPACE Water Treatment Compound**. Potential for the higher pH employed in water treatment should therefore be very good.

MERCURY (Hg): Recent discoveries of mercury in water and foods have led to a proposed standard of 5 ppb. We rated mercury compounds as highly toxic. The **AQUASPACE Water Treatment Compound** can be used on a commercial scale to remove mercury from concentrated caustic, various other solutions and waste effluents. Suspensions of finely divided mercury can be pressure filtered from a 50% caustic solution by the **AQUASPACE Water Treatment Compound** or by slow percolation through beds of the **AQUASPACE Water Treatment Compound**. Removals of 0.90-0.99+% are obtained in the low ppm range. Laboratory testing has shown virtually complete adsorption of 25-50 ppm Hg as CH3HgCl in tap water. Figure 1 shows the results of a column test over a three month period. Although it is not known at this time whether mercury occurs in ionic form in natural water, mercury (Hg+2)or mercurous (Hg+1) salts are believed to be reduced to the metal and adsorbed on the **AQUASPACE Water Treatment Compound**. It is known that old deposits of sedimentary mercury give rise to methyl mercuric chloride through biological action in surface water and this form is readily adsorbable.

COBALT (Co): Very little is known about the part cobalt plays in the human body. We rate cobalt compounds as only slightly toxic. No AWWA goal has been set. Prime interest from the health viewpoint would be in certain radioactivity of cobalt. Thesis work done on extremely low concentrations of cobalt demonstrates that practically

complete removal was obtainable with the **AQUASPACE Water Treatment Compound**. Best results were attained at a pH slightly over 7. Potential removal with the **AQUASPACE Water Treatment Compound** should be very good.

ZIRCONIUM (Zr): The inherent toxicity of zirconium compounds is low. No standard has been set. Zirconium is very strongly adsorbed at pH values of 2 and 3. Potential in water treatment applications should be very good.

POTENTIAL FOR METALS REMOVAL (fairly good)

Table 3 lists several metals of fair to good adsorption potential.

NICKEL (Ni): Nickel compounds are classified as only slightly toxic. No standards have been set for water. Laboratory studies in a nickel chloride solution show no adsorption at a pH of 2, slight removal at 5.4 and fair removal at 7.5. The possibility of removal during water treatment would be rated as fair to good.

TITANIUM (Ti): Titanium and its compounds are considered to be physically inert. No standards have been set. Metallurgical studies indicate 75% removal of titanium at a pH of 2.3. Potential for the **AQUASPACE Water Treatment Compound** in water treatment should be excellent. However, it is probably of little significance due to its low toxicity.

VANADIUM (V): Some vanadium compounds can have toxic properties, but reports seem to deal mostly with inhalation of dusts. No standards have been set. Metallurgical studies indicate that adsorption depends upon the specific vanadium compound present. Pentavalent sodium vanadate is strongly adsorbed at a pH of 1.5, yet at a pH of 7 adsorption is reduced dramatically. On the other hand, reduced ammonium vanadate is more readily adsorbed as the pH is increased from 0.5 to 5 suggesting a good potential of pH 7. The potentials for adsorption by the **AQUASPACE Water Treatment Compound** is highly variable.

IRON (Fe): A great number of studies have been conducted on chloride and sulfate solutions of iron. The **AQUASPACE Water Treatment Compound** displays very strong reduction properties, converting ferric salts to the ferrous condition in the absence of air. When an abundance of dissolved oxygen is present, the **AQUASPACE Water Treatment Compound** will act as a catalyst for the oxidation of ferrous iron to ferric iron, which is easily precipitated at pHs over 5. Both ferrous chloride and sulfate are adsorbed to some extent but not sufficiently to compete economically with precipitation methods presently used in the water field.

POTENTIAL FOR METALS REMOVAL (unknown)

Table 4 lists several elements of low or unknown potential. These are presently being tested for **AQUASPACE Water Treatment Compound** effectiveness.

COPPER (Cu): The AWWA goal has been set at 200 ppb, not because of toxicity, but because of the possibility of creating a taste. Laboratory tests at low concentrations, such as might be present in water supplies, showed some fair adsorption at a pH of 6 and higher. Efficiency falls off as the pH is lowered, to a point where no copper is removed at a pH of 3. Rating for the **AQUASPACE Water Treatment Compound** would be rather minor on copper compounds. A very recent study reports upon adsorption of copper cyanate as a method of cyanide removal. Since copper forms many complexes, potential adsorption through this route using less toxic agent would be promising.

CADMIUM (Cd): Cadmium has a high toxic potential and has caused sever cases of food poisoning. The AWWA goal has been set at 0.01 ppm. Studies on cadmium chloride solution at a pH of 5.2 showed some degree of adsorption so some slight potential should exist for the **AQUASPACE Water Treatment Compound**.

ZINC (Zn): Studies indicate that continued administration of small doses of zinc salts in man affected only digestion, leading to constipation. The AWWA proposed goal of 1 ppm has apparently been set for aesthetic reasons, chiefly taste. Laboratory tests on a zinc chloride solution at very low.