Planet Horizons
Technologies
Physical water treatment

PRESENTATION OF THE AQUA-4D® PRODUCT TO IMPROVE DECANTATION OF SLUDGES IN WASTEWATER TREATMENT PLANTS

Dr. Eric Valette, Director R & D

Planet Horizons Technologies SA, Technopôle 5, CH-3960 Sierre
Tel : +41(0)27 480 30 35 Fax : +41(0)27 480 30 36
info@planethorizons.com www.planethorizons.com

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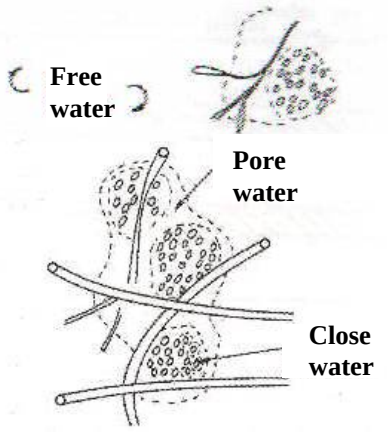
1. Introduction

The purification of wastewater inevitably leads to the production of sludge. Whether water ran through domestic or industrial processes, the quantity of suspended material can vary considerably. The rough materials are collected in the first tanks of the treatment plant where they constitute "primary sludge".
The finer materials, a polluting load in dissolved and colloidal form is treated afterwards. Generally, to eliminate this pollution, biological processes of purification (aerobic ones for the majority) are used, with bacteria which consume the biodegradable polluting material. These bacteria multiply themselves and it is necessary to evacuate this “living” sludge excess by decantation, what constitutes the "secondary sludge".

The physical properties of the flocs play a mayor role in this stage of gravitating separation. Morphology, size, structure (porosity, tortuosity, density), the floc composition and of major importance, the electromagnetic structures are various properties which will influence the quality of decantation. Operating conditions of the wastewater treatment plant such as the sludge age, the effluent residence time within the aeration tank, the composition of the effluent (very different behaviour from the communal effluents and the industrial effluents) as well as the load in substrate (relationship between the daily contribution of substrate and the quantity of biomass present in the aeration tank) are also likely to have an important influence, by modifying the properties of the floc previously quoted.

2. Floc composition

Flocs are in suspension in a medium where water is the main constituent (95 to 99% for the sludge in an aeration tank). This water can be classified in three fractions:
- pore water, trapped in the interstices of the floc;
- "close" water, which surrounds the bacteria in the floc;
- and the hydration water, chemically related to the floc, which can only be eliminated by a heat treatment.
If we are interested more precisely in the floc in his solid phase, we can classify it in three elements:



- micro-organisms;
- exopolymeric substances;
- linked water.

These exopolymeric substances (extracellular polymeric substances) accounts to an average of 10% of the mass of the flocs. They are either secreted by the metabolism and bacterial lysis and are composed of proteins, DNA, polysaccharides and lipids; or they come from the effluent itself (cellulose, humic acids, etc.). These exopolymeric substances play a very important role in the structure of the flocs due to their flocculating property; they have a double role in this process:
- by very complex biochemical mechanisms, this mucilage will allow the adhesion of the bacteria between each other, it is the phenomena called cementing;
- by physical mechanisms they also allow a neutralization of the electric charges, thereby avoiding the repulsive forces between bacteria. In fact, walls of the bacterial cells are

negatively charged whereas the extracellular polymeric substances are positively charged as a whole.

3. Mechanism of colloidal systems

The existence of the colloidal systems depends on the interaction between two particles. It involves two opposite forces:

- a repulsive force which tends to push the particles away from each other. This force depends on the load of the particles which are in the same sign;
- an attractive force (as Van Der Waals) which tends to gather the particles to reach the minimum potential energy. This force is, of course, depending on the distance between the particles.

To overcome the repulsive forces, two possibilities can be theoretically considered:

- increase of the kinetic energy of the particles (technically inapplicable in practice);
- modification of the resultant of the forces brought into the game.

We can achieve this by:

- increasing the ionic force of the medium by the introduction of an electrolyte, (which implies a reduction of the double-layer thickness);
- lowering the barrier of potential (known as potential Zeta) existing around colloid, by the introduction of an opposite-ion into the linked layer and adsorption of this opposite-ion on the surface of the particle.

Under these conditions, the particles approach each other sufficiently so that the Van der Waals forces become prevalent. The process which leads to this result is called coagulation.

Once this stage is reached, each collision between particles causes an increase of their agglomeration size; it is the phase of flocculation which leads to flocs of a size (order of millimetres) that allows their decantation.

Theoretically, any type of electrolyte can be used to obtain coagulation/flocculation of a colloid. However, it is recognized since many years that the effectiveness of a flocculating agent increases considerably with the number of oxidation (valence) of the cation of the electrolyte.

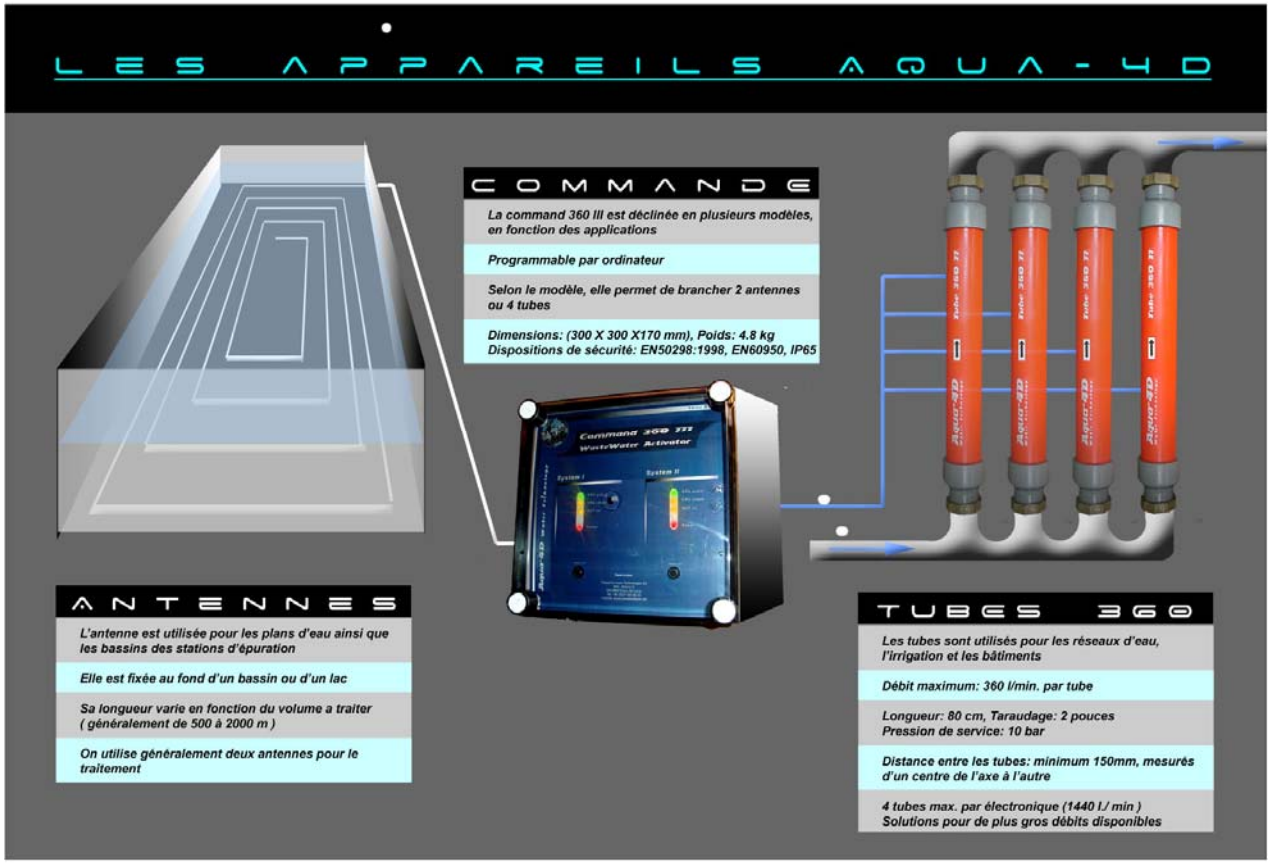
This is why ferric-iron and aluminium salts ($AlCl_3$, $FeCl_3$) which contain cations of an oxidation number of 3+ are almost exclusively used in the flocculation of water. Iron and aluminium salts present, in addition to their high valence, a tendency to hydrolyze themselves in the range of usual pH of natural water, to create an insoluble hydroxide which precipitates.

4. The Aqua-4D® electromagnetic treatment

An alternative way to the adding of chemicals coagulants is an electromagnetic physical treatment. It fulfils the interest to have extremely low operating costs (very low energy consumption) and does not comprise any disadvantage compared to the

coagulants/flocculating agents, who increase the quantity of produced sludge.

Our device is composed of a programmable command unit which generates a combination of frequencies (taking into account resonance frequencies and the mathematic ratios of biologic systems), with the possibility to regulate the intensity, the pulsation and the shape of the emitted signals. These signals are then diffused using transmitting antennas laid out in



the basin, their form and shape depending on the individual situation.

Our electromagnetic treatment makes it possible to lower the Zeta potential barrier existing around the bacteria in the same way as the introduction of an opposite-ion like $FeCl_3$ or $AlCl_3$, which allows overcoming the repulsive forces sufficiently so that the forces of Van Der Waals become prevalent. The phenomena of coagulation can thus be carried out without the introduction of chemicals and improve the decantation of sludge, with at least the same efficiency.

We can also facilitate the action of the exopolymeric substances whose role is very important for flocculation as we explained previously. A sufficient oxygen supply is indeed necessary to the function of mucilage. In the absence of oxygen, a fragmentation of the flocs appears. One of the frequencies chosen for our electromagnetic treatment was thus the resonance frequency of oxygen. We do not send molecular oxygen but we send directly into the medium the "electromagnetic signature" corresponding to oxygen. As we know from quantum physics, we can describe things as waves or particles, by knowing that all is finally vibration. With our approach, the advantage is that this signal is retransmitted to the whole sludge and penetrates much easier into the flocs, being thus accessible to mucilage.

Our electromagnetic treatment is also likely to modify the structure of the flocs in the direction of a stronger and more compact structure by influencing the "close water" and pore water.

We are continuing our research to determine exactly the mechanisms of action of our treatment on sludge. More important, that the excellent results obtained in laboratory tests and in a first field test shows us that the effectiveness of our treatment is very high.

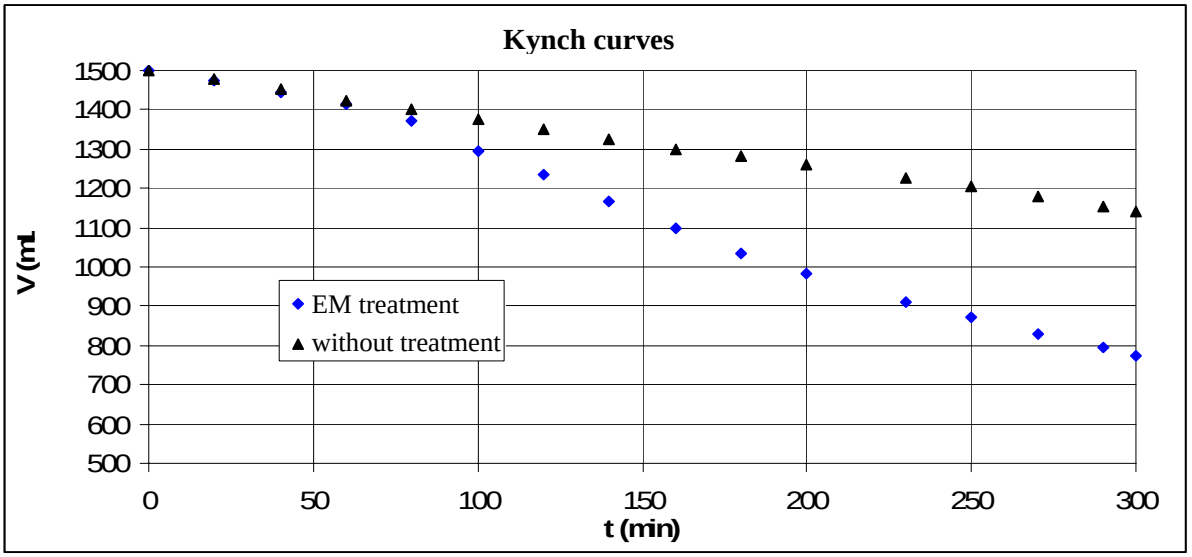
5. Results in laboratory tests

Since August 2004 we collaborate with the wastewater treatment plant of CIMO in Monthey, Switzerland. It is a large plant which treats wastewater of the community of Monthey and the surrounding ones. But the principal polluting load comes from the chemical industries of the area. The decantation of their sludge is rather slow and often problems arise.

From August to December we carried out many laboratory tests which enabled us to produce very encouraging results optimising the type of signals used in the electromagnetic treatment.

The tests carried out with sludge sample put in static decantation consists in recording the height of the interface (separation area between water and sludge) on a time axis. The obtained curves of Kynch enable us to define the effectiveness of decantation.

As we can see on the following example, it is perfectly visible that the decantation is largely improved by the electromagnetic treatment. The compressibility rate of sludge (i.e. content of dry materials of sludge) can be doubled, or the sludge residence time can be reduced up to 50 %.



6. Installation at the wastewater treatment plant of CIMO, Switzerland

Based on these results the wastewater treatment plant of CIMO decided to equip one of their decantation tanks with this new technology.
The installation was carried out in April 2005 in a 2'000 m^3 tank. The follow-up was carried out at the beginning by alternating several periods with our system switched on then off by comparing the effectiveness of decantation and the quality of the supernatant (clear water separated from sludge during the decantation). Then in the 2nd phase, the 2 lines (treated and untreated) were separated and put in parallel (with the starting of a second aeration tank in April 2006) in order to obtain righter comparisons. All the results obtained during these 2 stages have confirmed the effectiveness of our system.

7. Conclusion

Contrary to the continuous use of coagulants or flocculating agents, the operating costs with our electromagnetic treatment are almost inexistent since the necessary power supply is only a few watts, it is the type of the emitted signal which is important and not its intensity. Thus the emitted waves do absolutely not present any danger for the people nor can't disturb other installations. Moreover we do not have iron or aluminium ($Fe(OH)_3$, $Al(OH)_3$) which accumulates in the final sludge and which represents a considerable amount of sludge over the year.

In the case of difficult decantation situations, the adding of coagulants is often not sufficient to obtain a satisfying decantation. We saw that our treatment is much more effective than the use of coagulants, even more when the decantation is very difficult.

By reducing the residence time of sludge while keeping the same compressibility rate, our treatment also makes it possible to increase the entering polluting load without having to re-dimension the sludge tanks, because with the increase of the population, many wastewater treatment plants become under dimensioned and are a big problem.

In the same way we made tests with the thickening sludge of the wastewater treatment plant of CIMO and the results are also very interesting as they make it possible to increase the sludge compressibility rate and thus to reduce considerably the costs of dehydration. Moreover, we are convinced that the new structure of sludge obtained after our treatment allows a better effectiveness of dehydration, thereby saving costs at this stage as well as at the following stage of transportation and incineration.

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Planet Horizons Technologies SA