EC MICROBIOLOGY
Opinion

Hydrogen Sulfide: The Non-Invited Guest in Wastewater Treatment

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The definition of Earth as "Blue Planet" is not incidental. More than two thirds of the planet surface are covered by water. The same occurs inside our bodies: almost 70% of a person weight comes from water. The liquid element is essential for humans.

For millenniums humanity has learned how to transform and conduct that natural resource to use it for our desires: agriculture, industry, drink water, etc. Without the water technologies developed since the very first civilizations, we would not understand the world as how we do it nowadays.

However, water usage is indivisibly linked to water pollution. The first documented water treatment dates from 2000 BC in Asia. Further on, Egyptians and Romans applied filtration and coagulation and technology kept evolving until the contemporary age.

Cities and villages are connected underground with an endless pipes network that collect black waters form households and industries as well as the runoff water from sewers to a Wastewater Treatment Plant (WWTP). Cleaning water inside WWTPs consists on applying physical, chemical and biological processes to return the water body a quality, making it non-toxic for the ecosystem and reusable for human consumption.

Nevertheless, wastewater is a high complex environment. It has an elevated COD (Chemical Oxygen Demand) and BOD (Biological Oxygen Demand) due to the high carbon charge within it. Treatment wastewater systems generate a specific environment (slow flow rate, pH 5.5 – 7.5, 30 - 37°C, no oxygen), which is optimal for microorganisms that naturally produce metabolism by-products which are undesirable for humans.

Hydrogen sulfide (H2S) is one of the most problematic metabolites. There have been reported two main problems caused by the hydrogen sulfide: the odour nuisance (unwanted in residential areas and for WWTPs workers) and metal pipe corrosion.

Hydrogen sulfide is the final product of anaerobic respiration of sulfate ions solved in wastewater. The members of the non-taxonomical bacterial group known as Sulfate Reducing Bacteria (SRB) can perform a chemolithotrophic metabolism called dissimilatory reduction. Dissimilatory sulfate reducing bacteria are a heterogeneous group consisting of diverse phyla such as *Proteobacteria*, *Firmicutes* or *Nitrospirae*. Some archaea show that type of metabolism as well.

In the last second half of the past century, a lot of work has been done on studying hydrogen sulfide control in wastewater treatment. Strategies can be divided into chemical or biological.

Regarding chemical solutions, some authors have been focused on the problem in the inhibition of hydrogen sulfide after its generation. pH boosting by NaOH has been proved as an effective method to inhibit the Sulfate Reducing Bacteria activity [1]. At pH of 9 or higher, SRB are unable to grow efficiently and reduce sulfate to hydrogen sulfide. However, continuous NaOH feeding is expensive and may disrupt downstream treatment processes.

Metabolic inhibitors as Molybdenum and nitrite has been tested as biocides for SRB [2]. 100% inhibition was shown in SRB pure cultures in laboratory scale, yet experiments in real environments failed: biocides are not able to affect the cells living in tough biofilms generated in pipes.

Other strategies have been studied to specifically prevent SRB activity rather than unspecific bacterial inhibition. The growing biofilm is attached to a narrow slime layer above 0.4 mm very sensitive to the OD concentration in water. Many authors proposed oxygen injection in medium or terminal points of pipes to increase the OD and reduce the BOD [3,4]. Moreover, oxygen is non-toxic for downstream processes. Oxygen transmission in water is limited, therefore, effectivity of this method hardly depends on the physical and pressure characteristics of the pipe.

To control the hydrogen sulfide production, another approach has been done, focussed on the elimination of hydrogen sulfide once produced, rather than preventing its formation. Addition of alternative electron acceptors, such as nitrate, to wastewater has been found effective for hydrogen sulfide control. Denitrifying Bacteria growing in the same biofilm than SRB metabolise nitrate ions solved in wastewater by nitrate reduction, thus competing for the same space and ecological conditions and becoming an inhibitor for SRB metabolism. This is one of the best studied methods to solve H_2S problems. Different authors [5-8] have tested in real conditions the inoculation of nitrate-reducing, sulfide-oxidizing bacterium (NR-SOB) as *Thiomicrospira denitrificans*, *Thiobacillus denitrificans* and *Beggiatoa* spp.

Other chemical approach thoroughly studied is to oxidise the H_2S by the addition of different chemicals as hydrogen peroxide (H_2O_2) [9], Chlorine (Cl_2) [1]. Nevertheless, they have a short lifetime yield and attenuated by organic molecules present in wastewater.

Addition of ferrous (Fe^{2+}) or ferric (Fe^{3+}) ions led the precipitation of hydrogen sulfide into ferrous sulfide (FeS) [10]. Iron precipitation of sulfide has been proved as a generally rapid process, cost-effective and well-studied method. Despite, the sulfide breaking-up creates iron sulfides very insoluble in water that can stopple sewer systems and interfere in downstream processes.

In last decades, investigation has focused in environmental friendly solutions that fits the sustainable paradigm that humans face. Microbial fuel cells (MFCs) are devices capable of directly transform chemical to electrical energy by electrochemical reactions involving biochemical pathways. MFCs function on different carbohydrates but also on complex substrates present in wastewaters as sulfide. Dissolved sulfate in an anaerobic wastewater inflow as a fuel for the microbial cell showed encouraging results as an approach for a clean, cost-effective and sustainable control method, considering that electrical energy generated can be used as a source for water treatment system powering [11].

Another novel biological approach to hydrogen sulfide control is the use of phages. The lytic efficiency of a bacteriophage in *Desulfovibrio aespoensis* has been tested in SRB in laboratory scale with inspiring results. However, working with viruses implies a risk. Previous to a real application, it has to be demonstrated that the phage will not have any adverse effect on bacteria in activated sludge systems, water bodies, soil and human and animals gut microbiota, as we are the final consumers [12].

Indeed, hydrogen sulfide control in Wastewater Treatment Plants is not an arbitrary problem. Any of the studied solutions have the advantages to be defined as the ultimate solution for the problem. In the paradigm where we currently live, it is obvious that the scientific community has to rethink the investigation goals to make processes such as wastewater treatment sustainable. Probably, at least is what I expect, the final solution for the H_2S control in wastewater treatment will appear from biologic eco-friendly methods, for the good of the Earth and its inhabitants.

Conflict of Interest

Any conflict of interest as to be disclosed.

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