Phytotechnology in wastewater treatment of gold processing plants

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Phytotechnology is the application of plants to engineering and science problems. Phytotechnology uses ecosystem services to provide for a specifically engineered solution to a problem. Ecosystem services, broadly defined fall into 4 broad categories: provisioning (i.e. production of food and water), regulating (i.e. the control of climate and disease) supporting (i.e. nutrient cycles and crop pollination), and cultural (i.e. spiritual and recreational benefits). Many times only one of these ecosystem services is maximized in the design of the space. For instance a constructed wetland may attempt to maximize the cooling properties of the system to treat water from a wastewater treatment facility before introduction to a river. The designed benefit is a reduction of water temperature for the river system while the constructed wetland itself provides habitat and food for wildlife as well as walking trails for recreation. Most phytotechnology has been focused on the abilities of plants to remove pollutants from the environment. Other technologies such as green roofs, green walls and bioswales are generally considered phytotechnology. Taking a broad view: even parks and landscaping could be viewed as phytotechnology.

As a rule, at gold processing plants local processing of cyanide containing waters with oxidizing materials is used: they are chloride, hypochlorite, ozone, hydrogen peroxide as well as sorption treatment at coal filters, electrochemical oxidation. Each method has its advantages and disadvantages and in respect to specific conditions it is necessary to design treatment plan depending on technological regulations of gold extraction.

Recently there have been more and more projects to create new advanced reagentless methods of wastewaters treatment. Among such methods the most environmentally and economically efficient is plant technological advanced treatment.

S.S. Timofeeva shows that algae and water plants are resistant to cyanides by experiments. Concentration of cyanide of sodium 100 mg/l doesn't influence on growth responses of Elodea Canadensis, Scenedesmus quadricauda. On the contrary at cyanide concentration of 1-50 mg/l one can observe intensive growth of plants and increase of protein concentration.

Inhibition effect depends on pH, at pH 8-10 it is considerably weak, then at pH 6, which is the consequence of destruction of cyanides in acidic media and cyanide utilizing ability of microalgae and higher water plants.

Biochemical analysis proves the fact that within the experiment protein concentration in plants is constant or increases at high cyanide concentration (10-100 mg/l). Activity of oxidoreductase in plants at exposition on plants and solutions of cyanides in concentration of 10 mg/l (plant mass 5 g/l) is slightly changed, the difference is statistically inaccurate. Though it is known that cyanides are inhibitors of metallic ferments, the observed phenomenon can be explained by the system of cyanide detoxication in plants. Summarizing toxicometric experimental data one can judge that algae and water plants possess high toxic resistance to cyanide. There is no accumulation of cyanides in plants, they contain ferments, capable of the use of cyanide as a raw in biochemical transformations.

Cyanides are very toxic for animals but they are natural metabolites for plants. In references there are facts of existence of three possible ways of metabolism of cyanides in plants: reaction of replacement at β-cyanoalaninesynthase (KF 4.4.1.9), reaction of replacement at thiosulphitesulphidetransferase (rhodanese) (KF2.8.1.1.) and reaction of hydrolysis at cyanidehydrase (KF 4.2.1.66).

The most widely spread and studied in details is β-cyanoalaninesynthase, catalyzing hydrogen sulphide in the following chain

$HSCH_2CH(NH_2)COOH + HCN – NCCH_2(NH_2)COOH + H_2S$

It is stated that β- cyanoalaninesynthase is when a pyridoxaldependant lyase catalyzes reaction of replacement of cyanide by β -replacement. Products of reaction are hydrogen sulphide and β-cyanoalaine, which is transformed into cyanoalaninehydrase (KF 4.2.1.65) in L-asparagine, which is the source of amine groups for synthesis of other aminoacids or modification of protein molecules.

Up to our research it was considered that β -cyanoalaninesynthase is only in higher surface plants, in gramineous and legumes in particular has a function of original ferment at one of the stages of biosynthesis of asparagine (through cyanoalanine as an intermediate product). Hendrickson H.R, Conn E.E obtain refined products of cyanoalaninesynthase from mitichondrites of blue lupine and show that ferment is proteide pyridoxal –P and catalyzes the following reactions:

L-cysteine +HCN --- β - cyanoalanine + H_2S

O-acetylserine + HCN --- - cyanoalanine = CH3COOH

L-cysteine + CH_3SH ----S-methylcysteine +H2S

We are the first to state that higher water plant Elodea canadensis contains cyanoalaninesynthase. This ferment unlike surface plants is localized in cytoplasm which helps to utilize exogeneous cyanides and mercaptans of industrial origin coming into cell.

At capability to utilize cyanides and mercaptan compounds water plants and algae in the water bodies of the Asian part of Russia are studied.

Experimental research is performed at model ecosystems with introduction of cyanides, mercaptans, rhodanides, butyl xhanthate, butyl thiophosphate in certain concentrations and placement of water plant mass into them. According to classification of model ecosystems one can divide microcosm (less than 1 $м^3$), mesocosm (between 1 and 10 m^3) and macrocosm (over 10 m^3) by the amount (Lalli, 1990).

The plants are selected in the places of their growth, thoroughly sorted and conserved at the laboratories in dechlorinate water at temperature of -10-14 for psychrophilous and 20-25 C for thermophilic.

In microcosm solutions of cyanide of sodium or methylmercaptan of concentration from 0,1-100 mg/l and weighed hydrophytes from 0,1 up to 50 g/l are put and through certain periods of time water samples are selected and residual concentration of cyanides and mercaptans are analyzed. To assess contribution of physical and chemical processes experiments are performed in closed and open systems and without plants.

Experiments in mesocosm are performed in concrete reservoir with the capacity of 1 m3 directly at wastewaters treatment plants of GPP. As a macrocosm ponds of sludge pits of GPP are used.

Bioplato complex for wastewaters treatment consists of the following structures:

- structures of mechanical treatment, for industrial wastewaters – structures of physical and chemical treatment;
- filter units with vertical and horizontal water flow;
- ground units

  For gold processing plants plant technologies consisting of three stages in the following order are recommended:

  - 1 stage – charophytes with coverage density of 2,5 kg/m^2.
  - 2 stage – Elodea Canadensis with coverage density of 1,5 kg/m^2;
  - 3 stage – pondgrass and typha 30-40 $sample/m^2$.