# BIO-ENVIRONMENTAL PROTECTION, MATERIALS RECOVERY AND COST SAVING: THE CASE OF FLOTATION

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Flows of matter and energy from the first stage of production (depletion of natural resources of low-entropy materials) to the last stage of consumption (pollution of the environment with high-entropy wastes) imply a continuous deterioration of the biosphere. Technology can contribute to setting up a new model of matter and energy transformation with waste minimization and recycle maximization. The application of such technological innovations is not always economical and a bio-assessment of technology is needed for the re-orientation of applied research to the development of innovations of this kind, so that a network of bio-centric technological methods might be constructed. The operation of this network may lead to a holistic reconsideration of conventional patterns of technology, as it is suggested in a biopolitic scheme (1). Technology of bio-environmental protection constitutes unambiguously part of this network.

The processing of aqueous effluents from diverse chemical industries or from domestic sources has acquired great importance all over the world to meet stringent state regulations. The problem becomes very complex as a mixture of pollutants is involved and their amounts may vary vastly from 10 mg/l to 10% (2). In some cases (e.g. metol ions such as Hg, Cr, Co, Cd, etc.), it is necessary to bring down their amount in the final effluent to levels which may be as low as 0.5 mg/l. Further, many of the heavy metals may be refractory or even deleterious to biological treatment and would therefore call for special attention (3).

In considering processes which might be applied to both metal recovery and water recycle, to offset these costs, attention must be paid to the particular requirements of each situation. Referring to the overall water flowsheet at a factory shown in Fig. 1, it is clear that the objective must be to (4):

> Maximise: metal recovery and water recycle
> Minimise: disposal of toxic solid waste, make-up water and discharge and cost of treatment

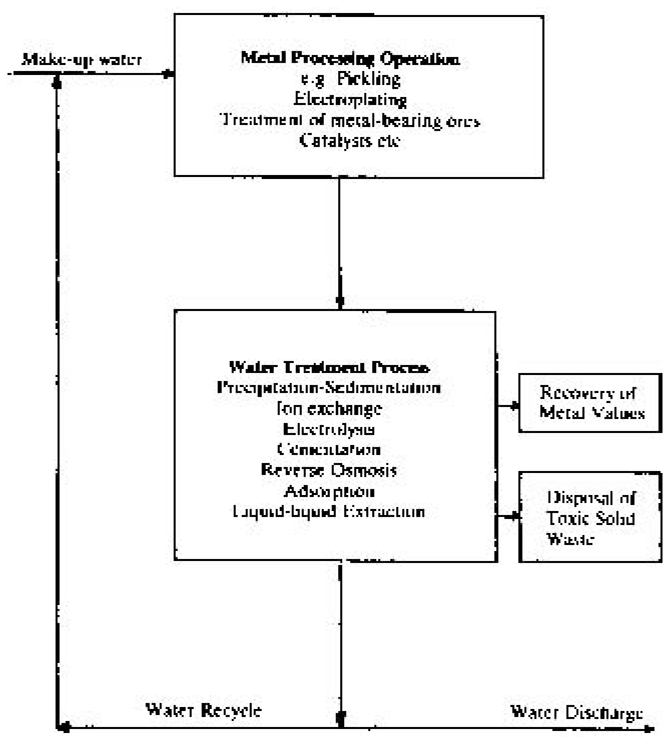

**Fig1.** Overall water flowsheet at a factory, showing the most probable water treatment processes.

Typical results obtained from chromium, arsenic, zinc, lead and germenium, with the appropriate conditions, are presented in Table 1 (5). A general scheme for germanium separation from the other elements (arsenic, zinc and lead), as a result of the conditions found, has been also suggested (6).

Pollution is generally viewed as an external cost, i.e. a cost that is imposed by one human activity on another without compensation. A rational method, named "internalization of external costs", to correct this "anomaly" is to ensure that any external cost (i.e. damage caused by pollution) is adequately paid for.

**TABLE 1**
**Optimum flotation conditions for the effective recovery of the examined pollutants.**

| Pollutant | Concentration | pH | Collector | Recovery |
|---|---|---|---|---|
| Arsenic | 10 ppm | 5.0 | Sodium Oleate | >90% |
| Chromium | 10 ppm | 8.0 | Dodecylamine | >80% |
| Germanium | 1.10 M | 7.0 | Dodecylamine | 95% |
| Lead | 1.10 M | 9.0 | Dodecylamine | 90% |
| Zinc | 10 ppm | 9.5 | Dodecylamine | >98% |

If we depict on a diagram the Marginal Social Cost of pollution (MSC) and the Marginal Cost of an effluent treatment (MCT) vs. the mean concentration C of the pollutant (caused by this effluent) in the system, then the optimum concentration (Copt) is directly obtained. When the effluent treatment is carried out by means of physical separation or "soft" technique (like flotation), which contributes to materials recovery and/or energy saving, then the curve MCT changes to MCT' and, consequently, a new optimal concentration C'opt Copt is achieved while the Marginal Cost (MC) corresponding to optimum level of pollution decreases from MC1 to MC2.

This superiority of soft techniques against chemical separation or "hard" techniques is not necessarily extended over the whole domain where a MCT curve is valid; a hard technique may exhibit a lower total cost, even without materials recovery and energy saving, over the whole domain or a significant part of it. The main efforts of applied research are soft methods and, especially in flotation, are directed to the development of techniques and to the optimization of conditions that contribute to the reformation of the corresponding cost function in the vicinity of Copt; such a reformation may result in a lower marginal cost even if the greater part of the new MCT' curve of the hard method (see e.g. the intermittent curve in Fig. 2, which depicts MCT' by means of a soft method proved to be superior in comparison with MCT).

Another significant reason that leads to the preference of a soft method with materials recovery and/or energy saving even if this method is slightly "more expensive": as economic growth increases the entropy (reduces the order, increases the randomness) of the nonhuman part of the biosphere, the relative scarcity of certain materials increases, having as an expected result the increase of prices in the long run; taking into account the present value of these materials instead of their current value, a "more expensive" soft method (like flotation) of effluent treatment combined with materials recovery and/or energy saving might be proven profitable (7).

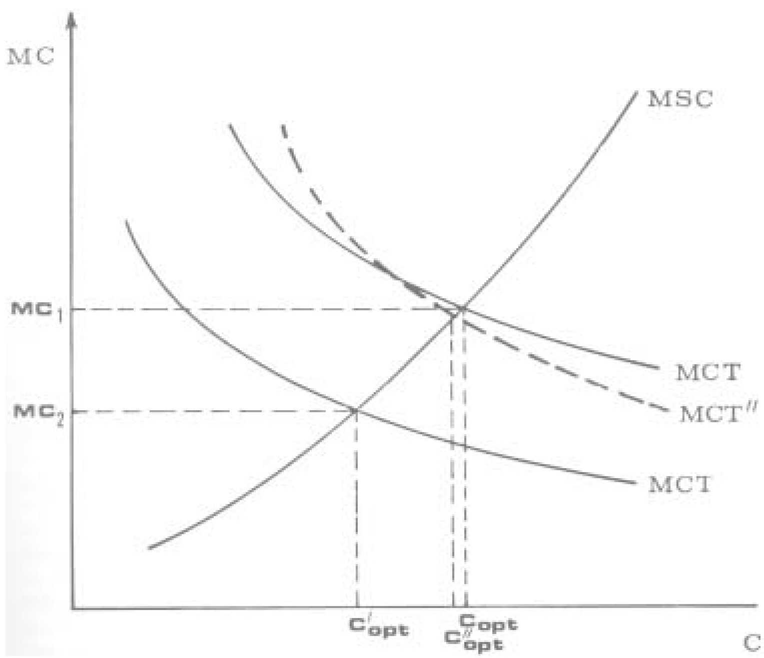


**Fig 2.** Determination of optimal concentration of pollutant in various situations.

There is evidence also, that better quality effluents are obtained due to the absence of entrained solids of fine particle size. It might be possible to make use of ion flotation for the removal of deleterious trace impurities or for increasing selectivity for particular metals, as was successfully tested in a previous work (8).

In concluding, rising environmental standards are making the processes of waste disposal more expensive. As disposal costs for effluent sludges rise, there is an incentive to process these for metals recovery. A firm should not look at the possibility of reclaiming materials from its toxic wastes solely from the angle "Will it pay?". A broader attitude might well bring them tangible benefits in the long run. In this paper the objective has been to introduce the flotation techniques into the technology of metal recovery from effluents.

There is obviously a need for a greater interchange of information between producers of waste, waste disposal contractors, and the reclamation industry, so that these recovery operations are facilitated. Effluent treatment and metals recovery are part of a rapidly developing industry promoted by the increased awareness of the values at stake. It appears to be almost certain that the application of modern techniques (like flotation) will allow most of the objectives to be achieved.

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