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Scenarios for Remediation of Polluted Air in Tropical Conditions

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ABSTRACT

In dealing with polluted environments that are difficult to recover, various remediation technologies are needed. Chemical and physical processes using mechanical equipment are difficult to avoid for quick handling. Furthermore, integrated intensification of bioremediation and phytoremediation is needed to optimize the results of long-term remediation. The purpose of remediation is to restore the quality of the environment so that natural functions function properly. This qualitative presentation provides the ability for evaluation and planning of remediation methods, which are specifically integrated phytoremediation and bioremediation for polluted air environments.
KEYWORDS: polluted environment, air remediation, bioremediation, phytoremediation

1. INTRODUCTION

Remediation technology is categorized into pollutants containment, separating pollutants from the medium, and pollutants destruction. The first two categories do not result in a reduction in pollutant concentration from the medium, whereas destruction results in a reduction in pollutant concentration [1,2]. Handling of contaminated media can be carried out at the place of pollution (in situ) or outside the place of pollution (ex situ).

Pollution localization is done immediately to prevent the spread of pollution. In fact, this method continues to be in the same place in the event that various technology choices are difficult to implement

Separation of pollutants from the media is done by washing water and extraction for solid media (soil, sediment). The liquid media (water, ground water) is contaminated by sedimentation, adsorption, stripping, and filtration. The polluted air medium is carried out by schrubbing, filtration, cyclones and the like.

Pollution destruction to reduce pollutant concentration from the medium is done by bioremediation and phytoremediation. Bioremediation technology can be done separately using microbial processes. Phytoremediation technology [3] works in an integrated manner between microbial processes and phytoprocesses.

This paper describes the air remediation scenario, which has so far been scarce studied and it is difficult to find examples of its implementation.

2. Air remediation

Air is the biggest ecosystem component compared to the water and soil components. Potential substances as air contaminants are mainly in the form of gases followed by liquid and solid forms. Sources of gas pollutants come from various life activities. Mainly are moving sources of transportation and settled sources of industrial and commercial areas as well as residential activities.

Green open space functions as a means of remediating polluted air without place restrictions. The use of mechanical vacuum pumps under certain conditions is needed to drain polluted air into the biofilter. However, the use of mechanical equipment can be effective and efficient for polluted air in confined areas.

Remediation of polluted air using biofilter, bioscrubber, photo-bioreactors, membrane bioreactors, and the like is effective and produces non-toxic air [1-5]. The effectiveness of bioremediation works especially well in biofilter with diverse materials and diverse microbes. The diversity of biofilter materials can be achieved through a mixture of natural materials (soil, sand), artificial materials (PVC pieces) and organic materials (compost). The diversity of these materials can foster a diversity of bacterial microbes, actinomycetes, fungi, yeasts, algae and protozoa [6]. Various types of microbes that are effective in bioremediation are presented in Table 1.

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Table 1: Microbial culture for remediation of polluted air

Pollutant	Microba	References
Benzene	*Pseudomonas putida, Phanerochaete chrysosporium*	[7]
Toluene	*Pseudomonas putida, Phanerochaete chrysosporium, Scedosporium apiosperm*	[8-10]
Styrene	*Exophiata jeanselmei, Phanerochaete chrysosporium, Xanthomonas* sp., mixed culture	[11-14]
Acetone	*Rhodococcus* sp., *Corynebacterium* sp.	[15]
Butanol	*Pseudomonas fluorescens, Corynebacterium tubrum, Micrococcus liiteus,* mixed culture	[15-16]
Isopropanol	*Pseudomonas fluorescens, Rhodacoccus*	[15]
Methanol	*Pseudomonas fluorescent,* mixed culture consortium	[15,17]
Ethanol	*Candida guilliermondii, Saccharomyces cerevisiae,* mixed microbial consortium	[13,18]
Dichlomethane	*Hyphomicrobium* sp., *Pseudomonas putida*	[8,19]
Dimethyl sulfide Hydrogen sulfide	*Hyphomicrobium* sp. *Chlorobium limicola, Thiobacillus* spp., *Xanthomonas* sp., activated sludge	[1,20-22]
Ammonia	*Alcaligenes, Pseudomonas, Arthrobacter, Nitrosomonas, Nitrobacter, Vibrio*	[23-24]

3. Biodegradation of organic substance

Bacteria and fungi have been studied for their ability to reduce various polluted environments. Airborne pollutants from water treatment, composting, food manufacturing, and the like, are generally very biodegradable in low concentrations. Biodegradable organic substances can be processed using natural organic media, or can be inoculated in mixed culture systems such as those found in activated sludge.

The main organic air pollutants are alkanes, alkenes, aldehydes, alcohols, ketones, carboxylic acids, esters, ethers, and aromatics. Various bacteria and fungal cultures have been identified to decrease organic pollutants. Some of them are in the case of acetone (Rhodococcus, Corynebacterium), butanol (*Pseudomonas, Rhodococcus*), dichloromethane (*Hyphomicrobium*), 1,2-dichloroethane (*Xanthobacter*), etanol (*Candida, Saccharomyces*), isopropanol *(Pseudomonas),* Methanol *(Pseudomonas),* methane *(Methylomonas),* phenol *(Pseudomonas),* and styrene *(Nocardia, Exophiata jeanselmei, Phanerochaete)* [25].

Air pollutants are mixed so that microbial reactions can compete or without competition, depending on the chemical structure of the pollutants [26]. For example, butyl acetate esters can inhibit the degradation of styrene in the processing of the butyl acetate and styrene biofilter [27]. But BTEX, methanol and H2S can be completely degraded [18,22,28].

4. Biodegradation of inorganic substance

Decreasing sulfur in dirty air can be done by microbes. The species is in the genus *Thiobacillus, Desulfobacter, Hyphomicrobium, Xanthomonas, Chlorobium* [22]. Green sulfur bacteria *Chlorobium limicola* can convert hydrogen sulfide (H2S) into sulfur in anaerobic conditions [24].

$$2nH_2S + nCO_2 \text{----->} 2nS + n(CH_2O) + nH_2O \qquad (1)$$

The Thiopaq process (H2S + 1 / 2O2 → S ° + H2O) describes the desulfurization process to produce sulfur elements from H2S contained in the air stream through oxidation of sulfur bacteria [22]. In this process, the first air flow is discrubber by washing with water flow, where the sulfur component will be dissolved in the liquid phase. Sulfide oxidizing bacterial species are *Thioalcalobacteria, Thiobacilli* or *Thlocalovibrio* can convert sulfides into sulfur elements taken using electron acceptors at neutral pH. The reaction steps are:

$H_2S + OH^- + HS^- + H_2O$ (scrubber) (2a)
$HS^- + 1/2O_2 \rightarrow S° + OH^-$ (sulfur-oxidizing bacteria) (2b)

The two stages of the process include the absorber and the filled bioreactor *Thiobacillus ferroxidan* to bring out the biological oxidation described in the reaction below [29]:

$H_2S + Fe_2(SO_4)_3 \rightarrow S\downarrow + 2FeSO_4 + H_2SO_4$ (absorber) (3a)
$2FeSO_4 + H_2SO_4 + 0{,}5\ O_2 \rightarrow SO_4^{2-} + S° + 2H_2O$ *(T.ferroxidans)* (3b)

Ammonia biodegradation uses a nitrification process, which converts NH3 to nitrite (NO^{2-}) and then (NO^{3-}) in two stages of the process. First, ammonia is oxidized by autotropic bacteria (*Nitrosotnonas* sp.) Reducing energy and biosynthesis by oxidizing NH3 to nitrite and carbon for the growth of CO2. Ammonia oxidation to nitrate using autrotropic bacteria can be written as follows:

$NH_4^+ + 0.5O_2 \rightarrow NO_2^- + 2H^+ + H_2O$ + energy *(Nitrosomonas)* (4a)
$NO_2^- + 0.5O_2 \rightarrow NO_3^-$ + energi *(Nitrobacter)* (4b)

Heterotropic nitrifier can also convert ammonia to nitrate. Heterotropic bacteria use the following method:

$NH_4^+ \rightarrow NH_2OH \dashrightarrow NO_2^- \rightarrow NO_3^-$ (5)
(Alcaligenes, Pseudomonas, Arthrobacter)

Nitrates produced during the nitrification process can produce N2 in the denitrification process. This process occurs in areas of low oxygen potential or anoxic zones that usually form in biofilms.

$2NO + 2H^+ + 2e^- \leftrightarrow N_2O + H_2O$ (6)

Microalgae have the ability to simultaneously reduce NO and CO2 in dirty air. Several microalgae have been found to be effective in reducing NO from the air using bubble column photobioreactors [30-31]. NO in the first gas phase is dissolved in a liquid phase, then oxidized and assimilated using algae cells. NO is directly absorbed by algal cells through diffusion as a source of nitrogen and for algal cell growth.

CONCLUSION

Localization and separation remediation technology is used for short-term treatment without producing a reduction in pollutant concentration. Destruction technology is used for long-term handling with the result of reducing pollutant concentration. Aerial phytoremediation can use existing natural infrastructure or building infrastructure specifically for remediation purposes. Phytoremediation works together with bioremediation in an integrated manner in the media in which plants are located.

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