Proceedings of the Third International Symposium on Air Quality Management at Urban, Regional and Global Scales. pp. 986-992, 26-30 September 2005, Istanbul – Turkey

ADAPTATION OF BIOLOGICAL WASTE GAS PURIFICATION SYSTEMS TO MEDITERRANEAN REGION

Emine Bolcu

University of Stuttgart, Institute for Sanitary Engineering,Water Quality and Waste Treatment, Bandtäle 2 D-70569 Stuttgart (Büsnau) / Germany
Emine.Bolcu@iswa.uni-stuttgart.de

ABSTRACT

Biofiltration technology has proved to lend itself not only to the reduction of odor emissions, but also to the prevention of air contamination with undesirable components. The goal of this study is to introduce this low-cost system to the developing countries especially in Mediterranean region. For this purpose, various agricultural and industrial waste products from Mediterranean region of Turkey were tested in a pilot biofilter plant to determine if they could be used as filter material in biofilters. In order to find out if they could be proposed as filter materials, the purification efficiency of a contaminated gas stream should be determined. Results of the researches propose that most of the tested waste products have the potential to be used as filter media.

Key Words: biofilter; Mediterranean region; waste gas treatment; filter material

1. INTRODUCTION

Biological waste gas purification processes, namely biofiltration, bioscrubbing, biotrickling have the advantage that they cause nearly no environmental problems as the pollutants are oxidized to harmless end products. They are preferred when large amounts of air with low pollutant concentrations have to be treated. These systems are based on the absorption of the contaminants in liquid phase and subsequent degradation of the absorbed contaminants into harmless oxidation products (carbon dioxide, water and inorganic compounds) by microorganisms. Compared with physical and chemical air treatment techniques, like adsorption and incineration, biological treatment techniques can offer advantages such as lower investment and operation costs.

The application of biological waste gas purification processes is based upon the ability of many microorganisms which oxidize a variety of organic and inorganic compounds into intermediate and/or mineral end-products (carbon dioxide, water etc.) and new cell material under aerobic conditions.

Since the early sixties biological methods have been employed for the purification of waste gases. It is somewhat surprising that the technological development of these methods, which are already being applied for the purification of wastewater at the beginning of this century, has taken a long time.

BIOFILTRATION TECHNOLOGY

Biofiltration technology has proved to lend itself not only to the reduction of odor emissions, but also to the prevention of air contamination with undesirable components. A small part of a long list of proven applications of biofiltration is: used oil processing, sewage treatment plants, slaughterhouses, animal feed production, bone processing, fat processing, lacquer production, plastics processing, polyester manufacture, sugar industry, coffee roasting and fish meal production.

Biological waste air treatment is based on the aerobic oxidation of the pollutant compounds by microorganisms. Among the biological waste air treatment processes namely bioscubbers, biofilters and biotrickling filters, *biofilters* are the most cost-effective and simple systems and they have the widest application area. They are applied mainly for the treatment of odorous gas streams and volatile organic compounds (VOC) containing waste gases with high removal efficiencies.

In general, the most important factor for an efficient biofilter is an optimum filter media. A biofilter consists of a box form filter bed which is filled with a solid media. As long as the environmental conditions like temperature, pH and moisture content in the filter media are optimal; the microorganisms would grow-up over the filter material and degrade the contaminants in the crude gas into harmless end products.

In biofilters, the treatment efficiencies are in general at high levels of till about 75-99 % if maintenance problems are not met. The primary maintenance problems in biofilters arise due to the filter material and difficulty in control of the moisture content in the filter bed.

The aim of this work was to propose agricultural and industrial waste products as alternative filter materials for biofilters especially in the regions with Mediterranean or similar climate.

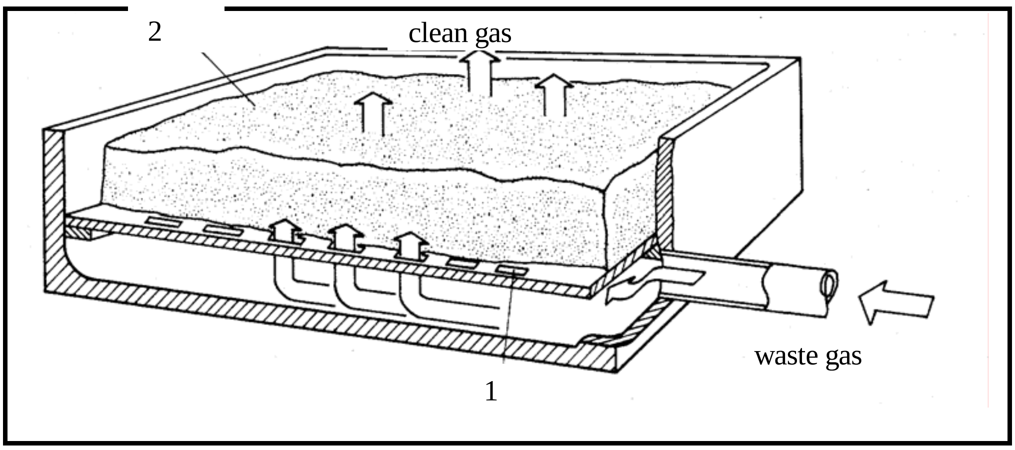

Figure 1: Single-level (open) biofilter (1 filter layer; 2 concrete base with slots for crude gas) (VDI 3477, 1991).

DETERMINATION OF POTENTIAL FILTER MATERIALS

The filter material, in other words the carrier material must simultaneously supply inorganic nutrients for the growth of the microorganisms. Therefore, mostly natural materials with a high content of organic compounds are used as filter material. But in some cases additional nutrients are needed to increase the removal efficiency. Other factors important for the selection of filter materials are: low pressure drops in the filter bed, high surface area, minimum addition of chemicals, long service life and minimum operation and maintenance costs.

The most commonly used filter materials are compost (of garbage, bark, leaf and paper) and peat. In order to decrease the pressure drop and to create a stable filter bed structure, these materials are mixed usually with a coarser fraction of other materials such as heather, bark, plastics, wooden chips etc. Some other inert materials are expanded clay and lava.

As stated by Devinny et al. (1999) careful consideration must be given to the choice of filter bed material so that its life expectancy is optimised and performance is maintained. It is important to choose a material with optimal chemical, physical and microbiological properties. As reported by Curran et al. (2000) smaller grain sized media would increase the elimination capacity, but the increased differential pressure would bring higher operation costs.

In Izmir, at the west coast of Turkey approximately 35 different materials through the agricultural and industrial waste products were collected. Some of those materials are bark of black pine tree, cotton seeds, bark of beech tree, pressed cotton capsule, branches of red pine tree, cones of black pine tree. The agricultural and industrial waste products are cheap and easy to obtain. In addition, they should not be processed before application. Therefore, they were chosen as alternative filter media.

Based on the experience, proven information and facts about the factors affecting the biofiltration process which are related with filter material, above mentioned materials were characterized in the laboratory in order to determine if they can be tested as filter materials in a pilot biofilter plant. *pH, conductivity, wet and dry density, porosity and nutrient content* determinations were implemented**.**

The results of these analyses were evaluated to determine only four of these to be tested in the removal efficiency measurements: *Pressed olive kernel (after oil production), bark of red pine tree (5-15 cm), grape vine (10-20 cm), branches of olive tree (10-25 cm).* They were then tested in a pilot biofilter plant which is shown in Figure 2 to determine their performance as filter material.

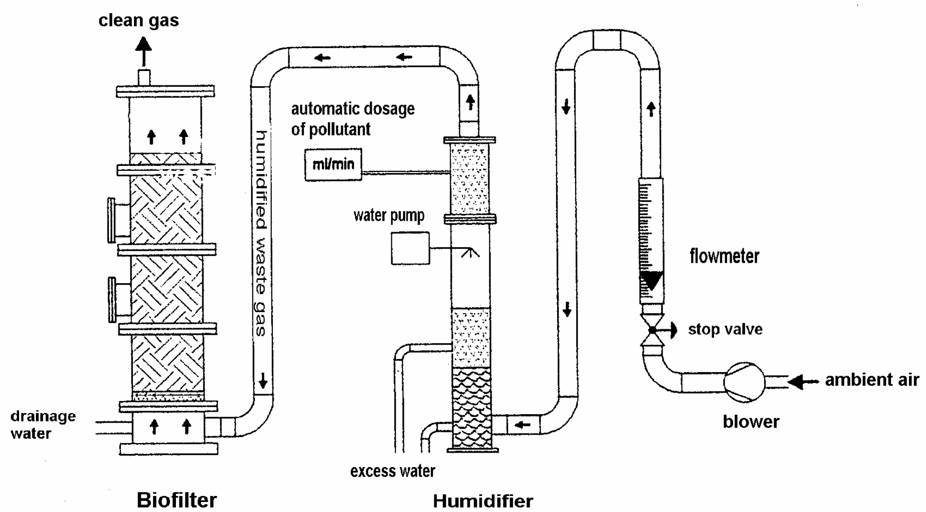

Figure 2: Schematic presentation of the pilot biofilter plant.

In order to determine if they could be proposed as filter materials, the purification efficiency of a contaminated gas stream was determined. In addition, pressure drop measurements were performed. Four experiments were implemented in a pilot biofilter plant to test each of the materials as a filter medium. Each experiment consisted of phases. In each phase, the treatment efficiency of a contaminated gas stream with different concentrations was measured. The flowrate and the dosage of contaminants were changed in each phase. As contaminants *2-butanon, 1-propanol and n-butyl acetate* were used. Typical biofilter loadings and extreme loadings were applied to see the difference in the removal efficiency by use of these alternative filter media. In addition, pressure drop in the filter height was regularly measured during each experiment.

The results of the total carbon removal efficiency measurements with the branches of olive tree as filter material in the first 30 days of the experiment are presented In Figure 3. The average purification efficiency was 80 %. This material was tested for five months in the pilot biofilter plant. The results of removal efficiency in the following days which are shown in Figure 4 were also above 80 %. This proves that the branches of olive tree are a good alternative to be used as filter material for the applications of biofilter in the Mediterranean region.

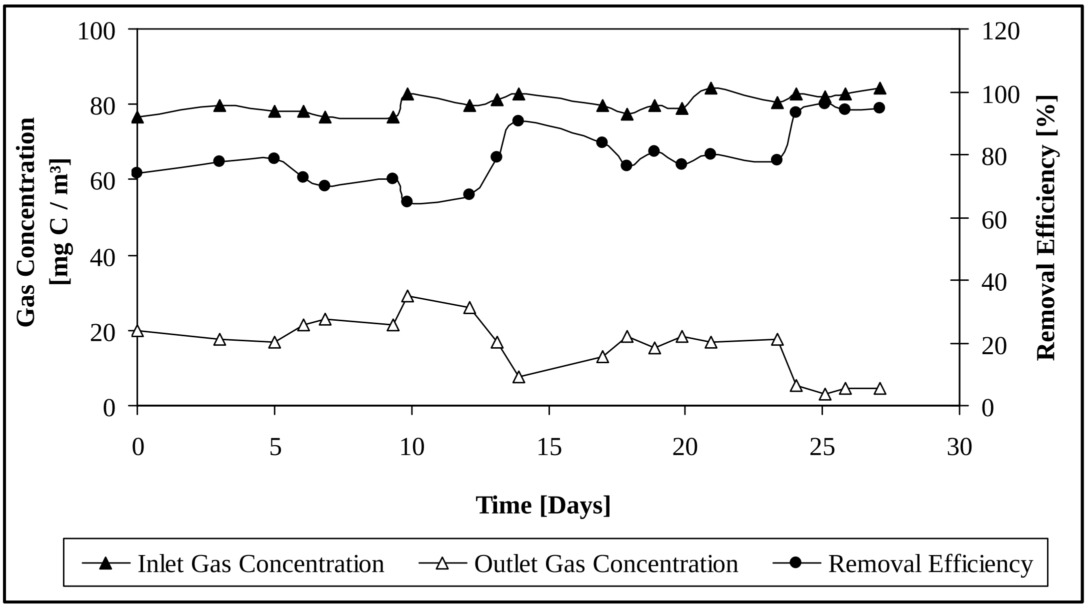

Figure 3: The results of removal efficiency measurements in pilot biofilter plant using grape vine as filter material during Phase A.

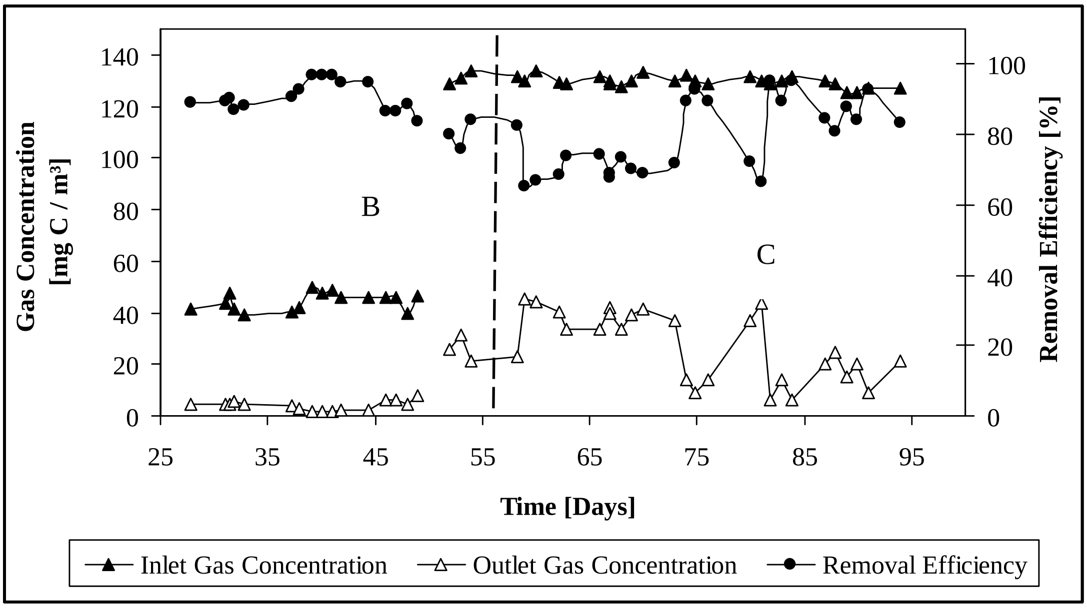

Figure 4: The results of removal efficiency measurements in pilot biofilter plant using grape vine as filter material during Phase B and C.

Changes in the process parameters during the series of measurements using grape vine as filter material are presented in Table 1. The average removal efficiency for the whole operation period was **80 %** for the inlet gas concentration in the range of 45-315 mg C/m³. Even for the extreme high inlet gas concentration of 315 mg C/m³ removal efficiency was almost 80 %. For the inlet air loading rates of 7-26 g/(m³**.**h), elimination capacity was in the range 5-20 g/(m^3.h). As a result, grape vine may be proposed as a filter material.

Table 1: Changes in the process parameters during the series of measurements using grape vine as filter material.

PHASE	**A**	**B**	**C**	**D**	**E**
Time [day]	0-27	28-49	50-94	95-122	123-140
Residence time [sec]	44.87	22.44	44.87	22.44	44.87
Flowrate [m^3/h]	10	20	10	20	10
Inlet gas concentration [mg C/m^3]	80	44	130	73	315
Outlet gas concentration [mg C/m^3]	16	4	27	14	73
Volumetric loading rate [m^3/(m^3.h)]	80	160	80	160	80
Elimination capacity [g /(m^3.h)]	5.1	6.4	8.3	9.5	19.4
Removal efficiency [%]	80	91	79	80	77

The performance of **olive kernel** was not good. The average removal efficiency for the whole operation period was **55 %** for the inlet gas concentration in the range of 80-170 mg C/m^3 as the filter bed was filled with olive kernel. Pressure drop in the filter bed was extreme high which makes the material less suitable to be used as filter medium.

During the filter operation with **bark of red pine,** the raw air loading rates varied between 5 and 20 g/(m^3.h) and the average removal efficiency for the operation period was **70 %** for the inlet gas concentrations in the range of 55-135 mg C/m^3.

Branches of olive tree showed a good performance. The average removal efficiency for the whole operation period was **80 %** for the inlet gas concentration in the range of 30-110 mg C/m^3 and inlet air loading rates of 5-14 g /(m^3.h).

3. CONCLUSION

Results of the researches propose that *bark of red pine tree, grape vine and branches of olive tree* have the potential to be used as filter media. Considering the removal efficiency, the optimal loading rate for these natural materials is up to 10 g/(m^3.h). Only grape vine may be operated with a loading rate of till about 25 g/(m^3.h) with a high removal efficiency.

Elimination capacity of the proposed materials is lower than the elimination capacity of well-known filter materials for the same contaminants. Consequently, these materials may only be proposed for crude gases with low concentrations of volatile organic compounds at this stage.

Finally, it can be concluded that bark of red pine tree, grape vine and branches of olive tree can be used as filter material for raw gases with a loading rate of till about 10 g/(m^3.h) with removal efficiencies of around 80 % especially in the Mediterranean and Aegean Regions. The proposed materials are most available in the countries of Mediterranean and Aegean Regions, especially in **Greece, Italy, Spain, France and Turkey**. So, the experiments show that the biofiltration can be adapted to the Mediterranean region by using materials which are available in the region as filter.

Biofiltration which is a simple and cheap system would find more application areas by the introduction of these cost effective filter media. These advantages increase the possibility of further applications of this technology in the developing countries of Mediterranean region which have financial problems in the field of environmental protection. The environmental conditions in these countries can be improved in this way.

4. ACKNOWLEDGEMENT

This study was supported by a scholarship from German Academic Exchange Service and by the Institute for Sanitary Engineering, Water Quality and Waste Treatment at the University of Stuttgart in Germany.

REFERENCES

Curran, T., Dodd, V., Sheridan, B., Colligan, J., 2000. Research Report 1999-2000, University College Dublin, Dept. of Agricultural and Food Engineering, Food Process Engineering.

Devinny, J. S., Deshusses, M. A., Webster, T. S., 1999. Biofiltration for Air Pollution Control. Lewis Publishers, P. 1-17, 41-79.

VDI Guideline 3477, December 1991. Biological Waste Gas/Waste Air Purification: Biofilters. Düsseldorf, Germany, P. 5-25.