Journal of Environmental Sciences Vol. 10, No. 3, pp. 479—484, 1998 ISSN 1001—0742

Eco-engineering for wastes treatment in process of alcohol production

Lu Bing-you, Wang Ru-song

DSE, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing 100085, China

Zhang Ren-wu

Agro-Environmental Protection Institute, Tianjin 300191, China

Sui Zhi-heng

Jilin Agro-Environmental Protection and Monitoring Station, Jilin 132000, China

Abstract—The strategies of coordination between production activities of alcohol and the comprehensive utilization of its by-products was discussed in this paper. It can be concluded from the study that guided by the principles of ecological engineering the purposes of both environment protecting and higher profits gaining can be realized simultaneously with less input than other engineering forms. Within this case, the by-products, CO_2, wastewater, distillers' grain, navel and mixed oil were treated as resources for certain purpose such as using as raw materials to produce fuel, forage and fertilizer. The rings earlier broken or given up by human behaviors were connected properly or added, and some high efficient rings were re-added. The economic benefits getting from the treatment of by-products occupy 10.39% of the total output or 1.17 times of the net output without environmental impacts.

Keywords: corn alcohol; ecological engineering; waste; Jilin of China.

1 Introduction

It has been for a long time a disturbed problem for human beings to find a trade-off between economic development and environmental protection. Because we can not and must not accept a situation of no environmental control, but we cannot afford zero-discharge policies either(Mitsch, 1989). But works must be kept doing, and waste materials such as waste material, waste gas and waste residues *etc*. would come into being accompanied aimed products continuously. Wastes come from generally three aspects, that is, little raw material without transferring into product thoroughly, diminutive output without getting recovered and other metabolic products produced during processing activities(Ma, 1987). In fact, there are no waste existing in natural world. The issue of waste is only a feedback of the degree of recognition for the availability of different resources in certain period. It would become a source of wealth if the consciousness of waste reusing increases with the strengthening of awareness of it and with the development of sciences. One of the most effective approaches dealing with this kind of problem is ecological engineering. Good examples have been showed in different areas either on purpose or in the ordinary course of event, for instance, in agriculture, forestry, mine restoration and so on. In this article, based upon a case study on the reusing of wastes produced in the process of edible alcohol in Jilin Province, China, the operating mechanisms and its results are discussed.

2 Site description

Jilin Alcohol Factory whose raw material is corn or corn flour, is a factory that its annual output is about 3000 ton. From the establishment of the factory till 1990, more attention was only paid to alcohol production, with little concern about the exploitation and utilization of most by-products. The by-products mainly include CO_2, mixed alcohol, wastewater, distillers' grain and navel which still could be used as good resources for other purposes. Therefore, financial deficit and environmental pollution always accompanied with its operation which blocked seriously the further development of this factory. In 1990, several approaches were adopted by the factory to reach the purpose of increasing the using rate of resources and reducing the discharge of wastes. This included a 1200 m^3 biogas tank construction, a 85000m^2 three-step oxidizing ponds construction and the recovery of other by-products(Fig.1). On behalf of these activities, the factory escaped from financing deficit and lightened the load of environment(Sui, 1995). The achievements that was gained of the factory are discussed bellow.

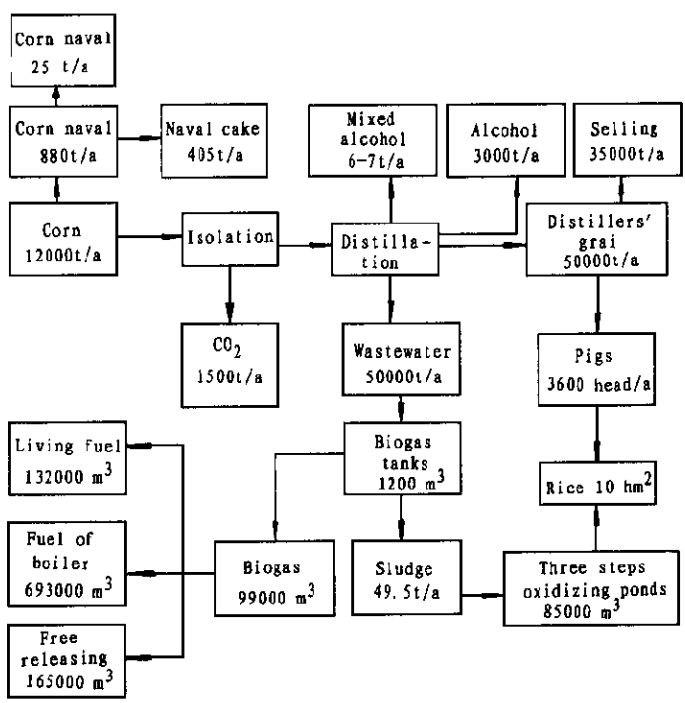

Fig.1 Flowing chart of matter in Jilin Alcohol Factory

3 Main principles and mechanisms of this type of eco-engineering

The system treated by eco-engineering is all complex system, which is recognized as an organic whole. The properties of a co-ecosystem are not equal to but more than the simple sum of those all of the components (Yan, 1992; Ma, 1984). All components of a co-ecosystem are interrelated and interactive. In other words, holism means system can not be separated. The objective for study, design and treatment in ecological engineering is not only the co-ecosystem itself but also

its relationship with the surrounding system (Yan, 1993). Practices however are not the same. Different subsystems or components of a system are isolated from each other by peoples' willingness not only in space but also in food chains. That brings in the very low performance both in parts and in system. For example, the connection between corn cropping and animal breeding is broken up traditionally owing to the burning of straw. Alcohol is opposite to environmental protection due to its poor treatment of waste. It is necessary for a holic system to maintain harmony and symbiosis. Comprehensive utilization engineering of corn in Jilin Province is a good example of integration of different parts into one system. The main principles include the combination of multiple industries, interface engineering and the harmony among nature, society and economy which is described in Fig.2.

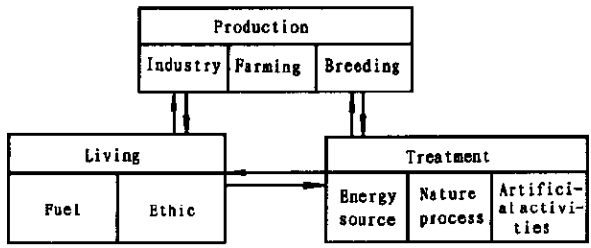

Fig.2 Relationship among three parts of the system

4 Input and output of materials in the ecosystem

Each year, after certain approaches being adopted, there are about at least five kinds of materials produced. Its area covers from forage, fuel, fertilizer and edible corn oil to industrial raw material. The results on the input and output of mass in the system is shown in Table 1.

Table 1 Input and output analysis of mass in system Unit: ton

	Input	Output							
				Forage				Industrial materials	
	Corn	Alcohol	Corn oil	Distillers' grain	Alcohol liquid	Fuel	Fertilizer	CO_2	Mixed oil
1990	12000	3000	0	0	50000	0	0	0	0
1995	12000	3000	25	405	50000	990000	50000	800	6—7

To produce edible alcohol, it is necessary to separate navel from corn fist(if the raw material is corn flour, this process can be omitted). The navel then may be used to extract oil while it is used as forage for livestock. According to the input of corn, the amount of corn navel is about 880 ton/year which can then be transferred into about 25 ton corn navel oil and 405 ton corn navel cake. After the navel is separated, the corn will be put into the process of saccharification and separation. During this process about 1500 ton CO_2 is released along with 800 ton of it using as industrial material in form of dry ice. Through distillation, the major product, edible alcohol, is produced followed by dry distiller's grains, waste water, and mixed alcohol oil. The distiller's grains, a kind of good forage for livestock, is sold to villagers around the factory or provided to the workers of the factory freely. The result of this action is more than 4000 pigs exportation each year. As for the waste water, a valuable organic carbon source and organic heat source whose temperature steadily keeps at 45—55 degree centigrade, with the concentration of COD of 10170 mg/L, may be used for biogas production. And the annual methane production in this factory is about 990000 m^3.

The methane can be used in different ways generally. For example, it is used as fuel for living

of household; as supplementary burning substance for creating electricity or heating boilers, or as antiseptic substance for vegetables and fruits storage. In this factory, three kinds of these ways are adopted. First, it is used as energy to meet the requirement of about 400 workers for heating and cooking. 132000m^3, about 13.37% of the total production is used for this purpose. Second, if the cost of electricity is higher, it will be used to produce electricity (in 1994, this action did not occur, because of the low cost of usage of electricity). Third, as a supplementary substance of burning, it can be used to heat boilers whose proportion accounts for about 70%, or 693000m^3. Owing to lacking of effective management and reasonable approaches for its further utilization, there is still 16.63% or about 165000m^3 methane discharged into the air automatically that results in certain degree pollution and economic loss. The integrated utilization, therefore, should be studied deeply in the future.

About 150 tons of residue or methane sludge are generated through fermentation each day, containing abundant organic substances such as sugar, protein and so on, which are harmful but nontoxic. In order to meet the national standards of waste water emission, a three-step oxidizing ponds with a volume about 85000 m^3, are built. Through this process the concentration of high containing COD waste water is decreased from 10170 mg/L down to 647.3 mg/L, while the contents of quick-active nitrogen, phosphorous and potassium containing in the waste water are 37, 8.5 and 4.0 ppm, respectively. As a results, the waste water is partly utilized to irrigate rice paddy or fruit trees. This not only results in a sharp dropping of the amount of chemical fertilizer, reduces the cost of the production and improves the quality of the soil and its products, but increases the yields of rice and fruits as well.

5 Function analysis

5.1 The major industry efficiency analysis

As mentioned above, the major product of this factory is edible alcohol. The output value of edible alcohol is 19.65 million RMB Yuan, which is 630000 RMB Yuan less than the input value. If the emission charge of waste water is added, the deficit may reach 810000 RMB Yuan.

5.2 By-products efficiency analysis

Compared to edible alcohol, the by-products mainly including corn navel cake, corn oil, mixed alcohol, dry distiller's grain and waste water which are all good resources either for industry production or for agriculture production. If some appropriate means are carried out, the profits produced may be big and can not be neglectful. For example, corn cake is a good forage for livestock breeding, corn oil is a healthy edible oil for human, CO_2 can be used either for industry or for agriculture purpose and so on. So, both for economic efficiency and for environmental efficiency, the by-products should be used sufficiently.

Table 2 shows the saturation of utilization of by-products and its profits. From this, we can conclude that the utilization of by-products is the key ring for getting profits. For example, since 1990, some approaches have been taken in the factory especially for the utilization of by-products and the return is excited. According to the data in 1994, the total income of the by-products reached 0.788 million RMB Yuan which makes up for the deficit of the major industry while at the same time some net profits about 0.158 millon RMB Yuan is gained. Among the output, corn cake and distillers' grains hold greater ports, about 38% respectively. But owing to the influence of the markets, further exploitation of by-products of this forms is limited, this in turn prohibits the promotion of the profits.

Table 2 By-products benefit analysis Unit: 10^3 RMB Yuan/a

Item	CO_2	Corn cake	Corn oil	Mixed oil	Distillers' grain	Pig	Total value
Output value	100	300	75	13	300	1512	2300

5.3 Interface engineering

Among the by-products, waste water is one that influences the environment mostly. The waste water is treated by methane production, a kind of interface engineering. After this operation about 3000 m^3 methane per day is produced which is mainly used as energy for living and production and as supplementary matter for boilers. The benefit obtained from this process is about 39.3 thousand RMB Yuan, 99.7% of the total output value, most of which comes from coal saving with the replacement of inferior coal to high quality one(Table 3).

The income generated from the methane liquid accounts for only about 0.3% of the total income of the methane production and this is mainly gained from the irrigating action and the reduction of chemical fertilizer input which is equal about 450 kg nitrogen per hm^2. This type of utilization of methane liquid is rather insufficient because many organic and inorganic nutritive substances are still contained in the waste water without efficient use. This implies the incompletability of the engineering and a big potentiality for its further development.

Table 3 Biogass benefit analysis Unit: 10^3 RMB Yuan/a

Item	Input		Output		Net output
	Discount	Emission charge free	Biogass	Sludge	
Value	10	0	393	5	388

If considering the depreciation of methane devices and the pollution charge, its net output of the system can reach 38.8×10^3 RMB Yuan. Therefore, the integrated exploitation and utilization of the methane liquid further more should become the first problem faced by this factory.

5.4 Systematic evaluation

It is obvious that of the 22.146 million RMB Yuan total output value, 2.3 million, about 10.39% of the total, is from by-products production including CO_2, forage, mixed alcohol and methane production 8.4%, 50.7%, 1.1%, 33.3% respectively (Table 4). Although the by-products proportion is not very high, it is an insurance of making up deficits and increasing profits, and solving environmental problems.

It is also shown from Table 4 that more than half of the benefit of by-products comes form forage production of residues which will not make any increase unless the scale of production expanded. However, if the use is more rational and more sufficient, methane production, accounting for 30% of the by-products income, should give a better performance, especially the integrated utilization of methane liquids.

Table 4 Systematic analysis on the balance of benefits Unit: 10^3 RMB Yuan/a

Input			Output									Net
Raw material	Discount	Charge fee	Total	Alcohol	CO_2	Navel	Distillers grain	Mixed oil	Biogas	Pig	Total	value
20280	100	0	20380	19650	100	375	300	13	398	1512	22146	1866

With the increase of profits, animal raising industry is also getting a great promotion followed the exploitation of high quality forage, and the living conditions of residents are improved with the

development of methane production. The most important one is the elimination of waste water pollution. In summary, broad prospects about the processing enterprises for agricultural products are presented themselves before our eyes.

6 Conclusion

It is a valuable exploitation for all of the enterprises faced the same problems, through it, we have seen a helpful future for both our rural and urban industries. Good beginning is half of success. It can be predicted that a big development in the process of industry following ecological engineering will be seen in not so long time. As a new exploitation form of the development of rural agricultural industries, it needs to be guided correctly, especially more input of scientific techniques and scientists.

Although great achievements have been gained, at least three kinds of problems still need to take into consideration. They are the insufficient utilization of CO_2; the lack of new approaches of methane reuse; the insufficient and irrational utilization of oxidizing waste water in accordance with the characters of water quality. If the three problems are solved better, greater profits can be expected.

Although the integrated profits of this kind of operation are not very high in this factory, it is a big transformation for the way of thinking and acting in coordination between economic and environmental returns in such kind of enterprises. During this process, wastes, originally called, are thought as resources; each of the production parts, originally separated purposefully, is combined into one part of the series processes; the environmental problems, the most confuced question in a long time for one factory, now are saved easily; and the efficiency of the factory is promoted greatly.

Although some shortcomings exists, as a good example in resources using and pollution treatment, the experience of this factory still is a good model for all enterprises facing the same kind of problems.

References

Gao Fang. Engineering measures for protecting ecological environment—wastewater pollution control. Beijing: China Science and Technology Press, 1992. 303—320

Ma Shijun, Li Songhua. Agricultural ecological engineering in China. Beijing: China Science and Technology Press, 1987

Mitsch W J, Jorgenson S E. Ecological engineering: An introduction to ecotechnology. NewYork: J Wiley & Sons Press, 1989. 3—12

Sui Zhiheng, Wang Li. Agricultural environment and development, 1995, 3:41—44

Yan Jingsong, Zhang Yushu. Ecological Engineering, 1992, 4:261— 287

Yan Jingsong, Zhang Yushu. Ecological Engineering, 1993, 2(3):193— 216

(Received for review October 14, 1997. Accepted December 5, 1997)