Status of Methane Emission in Sewage Treatment Process and Emissions Estimate in Henan Province

Bingtao Liu[1], Weiyan Zhao[2], Yalong Zhang[3]

School of Environment and Municipal Engineering, North China University of Water Resources and Electric Power, China

Abstract— *Methane produced during sewage treatment is a source of greenhouse gases which cannot be ignored. The estimate of methane emissions during wastewater treatment has an important significance for proposing methane reduction measures on the technical and economic feasibility. In this paper, the status of* CH_4 *emissions during sewage treatment of Henan Province is described. By obtaining the sewage treatment-related data and emission factor in Henan Province in 2010，* CH_4 *emissions in the year is estimated. The results show that* CH_4 *net emissions during domestic wastewater treatment is 21,764.10 tons in 2010 and that can evaluate the greenhouse effect and provide a basis for environmental management.*

Keywords— Methane, emissions, estimate, sewage treatment.

I. INTRODUCTION

Methane (CH_4) emissions caused by human activities include those energy activities, industrial manufacturing, agriculture activities, forest planting, animal husbandry and the process of living sewage and industrial wastewater treatment. Sewage biological treatment technology was oxidation and decomposition of the organic pollutants and plant nutrients in water and putting them into stable inorganic substance through Microbial metabolism of biological function itself. Sewage biological treatment technology is mainly composed of aerobic and anaerobic method. During the processing of the sewage aerobic method, mainly is use artificial aeration or natural aeration to provide oxygen for aerobic microorganisms, so that the organic matter is absorbed and decomposed, such as activated sludge, biological filter, rotating biological contactors and oxidation ponds. In the process of anaerobic wastewater treatment, organic matter in anaerobic conditions is a common action of anaerobic microorganisms, eventually be converted to CH_4, H_2S, and CO_2, such as sludge anaerobic digestion, anaerobic bioreactor and anaerobic pond. Organics in the condition of anaerobic or anoxic to produce CH_4, the most important emissions place is the aeration tank and anaerobic tank.

There are three methods to estimate methane emissions such as measured method, material balance algorithm and emission factor method. They have different features and complement each other. Emissions coefficient method is also known as emission factor method. The activity level data of coefficient method is the amount of emissions of unit product emission quantity under normal production conditions. It can generally be obtained by measurement, investigation and material balance method .In 2010, It has built 146 municipal sewage treatment plants and 27 town sewage treatment plants in Henan province and the provincial industrial and urban sewage emission is 3.587 billion tons. The industrial wastewater emission is 1.504 billion tons accounting for 42% of the wastewater emission and the urban sewage emission is 2.083 billion tons accounting for 58%. Chemical oxygen demand (COD) of the main pollutants is 619700 tons. In this paper, we adopt IPCC emission factor method and calculate the emissions of methane in the sewage treatment process in Henan and the results are analyzed and discussed.

II. ESTIMATE OF METHANE EMISSIONS IN THE PROCESS OF SEWAGE TREATMENT

2.1 Estimation method

By acquiring the sewage treatment-related data and emission factors，CH_4 emissions in Henan Province in 2010 was estimated according to the method recommended by IPCC. The specific formula is as follows,

$$E_{CH4}=(TOW\times EF)-R \qquad (1)$$

Where,

E_{CH4}, total amount of sewage treatment methane emissions (tons CH_4 / year)

TOW, total organic matter emissions of living sewage treatment (kg BOD / year)

EF, emission factor (kg CH_4 / kg BOD)

R , amount of recovered methane（ kg CH_4 / year)

$$EF=B_0\times MCF \quad (2)$$

Where,

B_0, the maximum production capacity of methane (kg CH_4/kg BOD);

MCF, the correction factor of methane

2.2 Activity level data

Activity levels data of methane emissions is the total amount of organic matter biochemical oxygen demand (BOD) as important indicators, including BOD discharged into the environment oceans, rivers or lakes and the part of removed in the sewage treatment plant processing system. Because only own the statistics data of chemical oxygen demand (COD). So we use the conversion correlation between the regional BOD and COD and shown in table 1.

TABLE 1
DIFFERENT REGION BOD/COD AVERAGE VALUE

Different region	Northern China	Northeast	Eastern China	Central China	Southern China	Southwest	Nationwide
BOD/COD	0.45	0.46	0.43	0.49	0.47	0.51	0.46

Amount of emissions of municipal wastewater is 2.083 billion tons In Henan in 2010.We know only Zhengzhou Wangxinzhuang sewage treatment plant has sewage methane recovery and recycled methane was 7 million cubic meters one year. According to methane density 0.00067 t/m^3, we can calculate the amount of methane recovered was 4,690 tons in Henan in 2010.

2.3 Emission factor data

MCF indicates the degree of achieve methane maximum production capacity through different treatment and disposal system (B_0) and also reflects the anaerobic degree of system.MCF can use the following formula,

$$MCF=\sum_i WS_i \times MCF_i \quad (3)$$

Where,

WS_i, the proportion of type i wastewater treatment system for municipal sewage treatment

MCF_i, the correction factor of methane of type i wastewater treatment system

According to the actual situation and using the related parameters, it is concluded that the national average MCF is 0.165.

TABLE 2
URBAN LIVING WASTEWATER EMISSION FACTOR

Category	MCF	B_0 (kg CH_4/kg BOD)	EF (kg CH_4/kg BOD)
Sewage treatment system	0.165	0.6	0.099
Discharged into natural water bodies	0.100	0.6	0.06

Methane maximum capacity which means that organic matter in wastewater can produce the biggest methane emissions, per kilogram of living wastewater BOD can produce methane 0.6 kg. Also emission factor should be determined in accordance with the specific circumstances. Because Henan province is in central China, we can know the recommended conversion value between BOD and COD value is 0.49. Other emission factors detail in table 2 and according to the formula (2) calculate EF of the sewage treatment system and EF discharged into natural water.

2.4 Estimate the result and analysis

According the mechanism of methane emissions, CH_4 emissions estimate from sewage can be divided into two parts, one produced in the process of sewage disposal and CH_4 produced in the process of wastewater discharge, the other one produced from untreated living sewage discharged into the environment. Therefore methane emissions estimate from the maximum living waste water. From values in Table 1 between BOD and COD, we can emissions 254604 tons of the living sewage treatment plants and remove BOD 21805 tons of natural water.

According to the activity levels data and emission factors in table 1, and BOD of processing system. We can calculate the methane emissions of sewage treatment in 2010 in Henan province show in Table 3

TABLE 3
LIVING WASTEWATER TREATMENT METHANE EMISSIONS STATEMENT IN 2010

Sewage treatment	Total Organic Matter (TOW),tons,BOD	Emission Factor(EF) (kg CH_4/kg BOD)	Methane Recovery(R),tons
Sewage treatment plant	254604	0.099	4690
Directly discharged into natural water	21805	0.06	0

According to table 3, methane emissions estimates of sewage treatment plant was 25205.80 tons in Henan province in 2010. Methane recycled capacity of sewage treatment plant was 4690 tons. Methane emissions of sewage treatment discharged into natural water was 1248.3 tons. We can also know that sewage treatment produced 26,454.1 tons CH_4. The net methane emissions of Henan province sewage treatment is 21,764.1 tons in 2010 and equivalent to 457,046.1 tons carbon dioxide.

III. SEWAGE TREATMENT METHANE EMISSIONS ANALYSIS

Comparing the methane emissions of sewage treatment plant in 2010 and in 2005, we can found that emission of sewage was 1.39088 billion tons in 2005 while sewage treatment plant recycled and disposed 930.75 million tons. It is concluded that sewage treatment rate was 66.92%. In 2010, emission was 2.01468 billion tons while sewage treatment plant recycled and disposed 1.85560 billion tons that sewage treatment rate was 92.10%. We can see that the sewage treatment rate greatly promoted in 2010 relative to 2005.It should thank to investment and construction of sewage treatment plant. By the end of 2010, It has built 146 city level sewage treatment plants and 27 township level sewage treatment plants. But 31 municipal sewage treatment plants have been built in 2005 in Henan. Comparing 2010 and 2005, the methane net emissions increased from 14676.41 tons to 21764.1 tons and sewage treatment system produced 25205.8 and 9030.14 tons CH_4. Because of the construction of sewage treatment plants in Henan Province in recent years to speed up . Treatment capacity increased significantly and total BOD remove obviously. Sewage directly into natural water and treated sewage discharged into natural water produce 1248.3 tons CH_4. There was a substantial decrease compared with 5646.27 tons in 2005. The total quantity of CH_4 produced in the process of sewage treatment was 26454.10 tons in 2010. CH_4 net emission in the sewage treatment process was 21,764.10 tons and 82.27% proportion. Recovery amount of CH_4 was 4690 tons, accounting for 17.73% of the total amount. It was a major breakthrough compared with the zero recycled in 2005.Methane emissions comparing 2010 and 2005 show in table 4.

TABLE 4
METHANE EMISSIONS COMPARISON 2010 WITH 2005

Years	Sewage volume (million tons)	Into natural water CH_4 (tons)	CH_4 produced in Processing system (tons)	Recovery amount of CH_4 (tons)	Total CH_4 capacity (tons)	Net CH_4 emissions (tons)
2005	13.91	5646.27	9030.14	0	14676.41	14676.41
2010	20.15	1248.30	25205.80	4690	26454.10	21764.10

IV. CONCLUSION

This paper chose activity level data in the sewage treatment process in recent years and the relevant emission factor which think the actual status of CH_4 emissions. According to the method recommended by IPCC guidelines for national greenhouse gas inventories 2006, a calculation model was established to assess methane emissions of wastewater treatment in Henan.

Methane emission from sewage and industrial wastewater treatment process was estimated. In 2010, net CH_4 emissions from sewage treatment process are 21764.1 tons. Through the analysis of CH_4 emission from sewage treatment, we can see that the net emissions of CH_4 in 2010 was 7087.69 tons more than that of 2005. Clean development mechanism (CDM) of anaerobic denitrifying of sludge in sewage treatment system will be the next focus.

ACKNOWLEDGEMENTS

Thanks to the financial support provided by the Henan development and Reform Commission

REFERENCES

[1] DING Weixin, CAI Zucong.The influence of temperature on the methane production and oxidation, Journal of applied ecology, 14(4),604—608 ,2003

[2] LIU Yan,SUN Dezhi,LUN Xiaoxiu.Advanced research of the produce,emission character and influence factor of CH4 discharged from the sewage transport and treatment.,Environment Pollution and Control, 34(5), 91-95,2012

[3] IPCC. Climate Change 2007: Mitigation of climate change, Contribution of working group to the fourth assessment report of the intergovernmental panel on climate change. Cambridge, UK and New York, USA: Cambridge university press, 2007.

[4] Otte S, Seviour R J, Kuenen J G, etal. Nitrous oxide production by alcaligenes faecalis during feast and famine regimes. Water Res, 34(7) ,2080-2088,2000.

[5] Hanaki K, Zheng H, Matsuo T. Production of nitrous oxide gas during denitrification of wastewater. Water Science and Technology, 526(26),1027—1036,1992.

[6] Garrido J M, Moreno J, Mendez-Pampin R. Nitrous oxide production under toxic conditions in a denitrifying anoxic filter,Water Research,32(8), 2550—2552,1998.

[7] Schulthess R V, Wild D, Guger W. Nitric and nitrous oxide from denitrifying activated sludge at low oxygen concentration,Water Science and Technology, 30(6),123—132,1994.

[8] YU Yang, CUI Shenghui,Lin Jianyi,etal,Study on greenhouse gas emissions from urban waste disposal system: A case study in xiamen,,Environmental Science, 33(9), 3288-3294,2012.

[9] Takaya N, Catalan M A B, Sakaguchi Y. Aerobic dentrifying bacteria that produce low levels of nitrous oxide. Applied and Environmental Microbiology, 69(6),3152-3157,2003.

[10] Gianfranco Chicco, Pierluigi Mancarella. Assessment of the greenhouse gas emissions from cogeneration and trigeneration systems. Part I: Model and indicators ,Energy, 33(6),410-417,2008.

[11] Tsao Chou Chen, Cheng Feng Lin. Greenhouse gases emissions from waste management practices using life cycle inventory model, Journal of Hazardous Materials.155,23-31,2008.