EMISSION ESTIMATION TECHNIQUES FOR AMMONIUM NITRATE PRODUCTION

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In the present study, an estimation calculation system is described according to the literature reviews available in Asian and European countries on the minimization of industrial emissions. On the basis of the calculations done, an approach is described for the calculation of emissions, and the procedure mentioned in the article, and referred to the National Pollutant Inventory (NPI) is also described.

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INTRODUCTION

A commonly used method for industrial fertilizer production and its emission calculation are described herein. Chemical fertilizer production is a process in which physical and chemical reactions take place[1]. The main purpose of this work is to investigate the changes in chemical structure that occur during fertilizer production. Different fertilizers are used in a variety of sectors depending on their chemical and thermal properties[2]. Table 1 outlines the most common fertilizers together with their compositions. One of the most commonly used fertilizers in the mining industry uses a mixture of ammonium nitrate and fuel oil[3]. The main products of the combustion of this mixture are CO, CO_2, NOX, and H_2O. For example, in Australia, it is estimated that the mining industry uses at least 600 000 tonnes of this mixture per annum [4].

EMISSION SOURCES AND CONTROL TECHNOLOGIES

Emissions to Air

Emissions to air can be categorized as follows[5]:

Fugitive Emissions

There are many different emission forms from fertilizer production plants. Fugitive Emission is the waste form in the outline of a planned process. The chemical compositions of waste materials are different depending on the particular fertilizer. The emission factor is used for determining the mass loss.

Point Source Emissions

In terms of fertilizer production, this emission form concerns the waste gas emitted from a planned point. There are several reviews available in the literature regarding this form of emission.

Emissions to Land

This describes the discharge of emission sources that are collected as waste water in production plants. There are several appropriate control technologies for emission reduction, each of which has a certain control efficiency. In this study, uncontrolled emissions are measured using some form of control technology and are classified according to their “emission factor”, as given in Table 2.

MATERIALS AND METHODS

An engineering calculation is an estimation method based on physical/chemical properties (e.g., vapor pressure of the substance) and mathematical relationships (e.g., ideal gas law). Example 1 shows how emissions of dinitrogen monoxide can be calculated. Some information is available on the chemical decomposition of fertilizers, so that the amounts of some substances listed in the National Pollutant Inventory (NPI), produced from the combustion process (e.g., carbon monoxide), can be calculated theoretically.

Table 1. Compositions of Fertilizers

Fertilizer	Composition
NPK	75/10/15 Nitrogen/Phosphorous/Potasium
Nitrate compounds	20–60% ammonium nitrate and sodium nitrate
Ammonium nitrate	Ammonium nitrate with 5.8–8% fuel oil
Amine complexes	Cyclotrimethylenetrinitroamine

Example 1. Estimation of dinitrogen monoxide Emissions from the Production of Ammonium Nitrate

The result of the production of ammonium nitrate is represented by the following general reaction series, which forms the basis of the worked out example.

The final products of the production of ammonium nitrate are:

$$NH_4NO_3 \rightarrow 2N + 4H + 3O \quad (1)$$

a) $2N \rightarrow N_2$
b) $4H + 3O \rightarrow 2H_2O$ (1 O remaining)
c) $2N + O \rightarrow N_2O$

The loss during the production

$$NH_4NO_3 \rightarrow N_2O + 2\,H_2O \quad (2)$$

Total molecular weight of NH_4NO_3: (2×N) + (4×H) + (3×O)== (2×14) + (4×1) + (3×16) = 28 + 4 + 48 = 80. Total Molecular weight of N_2O = 14×2 + 16= 44 kg mol^{-1}. Total weight of N_2O from reaction = 1 mol × 44 kg mol^{-1} = 44 kg. Total N_2O emission = (44/80) ×1000 kg t^{-1} = 550 kg of N_2O produced per tonne of ammonium nitrate

Emission Factors

The emission factor is a tool used to estimate emissions to the environment. In this paper, it relates the quantity of a substance emitted from a source to some common activity associated with those emissions. Emission factors are obtained from US, European, and Asian sources, and are usually expressed as the weight of a substance emitted divided by the unit weight, volume, distance, or duration of the activity through which the substance is emitted[6].

Emission factors are used to estimate a facility's emissions by the general equation:

$$Ekpy_i = A * OpHrs * EF_i \left[1 - \frac{CE_i}{100}\right] \quad (3)$$

where:

$Ekpy_i$	-	emission rate of pollutant *i*, kg yr^{-1}
A	-	activity rate, t h^{-1}
OpHrs	-	operating hours, h yr^{-1}
EF_i	-	uncontrolled emission factor of pollutant *i*, kg t^{-1}
CE_i	-	overall control efficiency for pollutant *i*, %

Emission factors determined from measurements for a specific process can sometimes be used to estimate emissions. If a company has several processes of similar operation and size and emissions are measured from one process source, an emission factor can be determined and applied to similar sources. Examples of uncontrolled emission factors for fertilizers are given in Table 2.

Available theoretical, complex equalities and models in the literature are used to calculate the emission amounts during the production of fertilizers such as ammonium nitrate.

The use of equalities for the estimation of fertilizer production is more complex than the use of emission factors. Emission equalities require more data, but they ensure more accurate estimation depending on the specific conditions.

Discussion

The main aim of this study is to ensure the realization of industrial production processes with sensitivity to the environment, and the development of new methods in order to obtain the best possible results. With this aim, new methods and models have recently been recommended to allow the description and better understanding of frequently mentioned emission problems.

With regard to the emission factors calculated by the NPI method (Table 2), it is clear that the emission levels need to decrease. For this, there are four methods for emission estimation provided in the NPI guidelines. In general, there are four emission estimation methods in the NPI Guidelines for production processes[7]:

- sampling or direct measurement;
- mass balance;
- fuel analysis or other engineering calculations;
- emission factors.

Any of these methods can be selected. For example, the mass balance method can be used for fugitive emissions. For the calculation at a detected point, the use of emission factors is a more suitable approach. Emission data estimated by using any of these methods will be displayed on the NPI database as measurements of "acceptable reliability."

Emission sources in fertilizer production are common. These may be different according to the type of fertilizer produced. Emission problems during production can be mitigated if we know what action the manufacture should take to decrease emissions. For this purpose, the preferred method of the known emission calculation methods is that of emission factors. Each emission factor is described by an emission factor rating (EFR) code[8]. This rating system is common for all similar industries. When using the emission factor approach, the emission factor code and its meaning should be understood. Ratings A and B describe bigger and more certain ratings than D and E. The given emission factor is not representative for a specific source or category.

The EFR system is as follows:

A - Excellent

B - Above Average

C - Average

D - Below Average

E - Poor

U - Unrated

Table 2. Uncontrolled Emission Factors for Fertilizers

Fertilizer	**Emission factor (kg ton^{-1})[a]**					
	Carbon monoxide (CO)	Nitrogen Oxides (NO_X)	Ammonia	Hydrogen cyanide (HCN)	Hydrogen Sulfide (H_2S)	Sulfur dioxide (SO_2)
Nitrate compounds	32	ND	NA	NA	16	NA
Ammonium nitrate	34	8	NA	NA	NA	1
Amine complexes	98	ND	22	NA	NA	NA
NPK	85	ND	NA	NA	12	NA

Source: Adapted from USEPA Document AP-42 (1995); [a] Units are kilograms (kg) of substance emitted per tonne (tonne) of fertilizer used; ND - No data available; NA - Not applicable.

Conclusion

The most effective emission estimation techniques have been investigated according to the NPI values for emission estimation. As expected, direct measurement is the most reliable method for emission characterization. However, results from other calculation methods can be considered. For typical emission problems, there are four methods found in the literature for measuring emissions from a particular source. It should be mentioned that the emission of material mass to air, water, and land should be calculated using every method.

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