St. Lawrence TECHNOLOGIES

HAZARDOUS WASTES

EVALUATION OF PHOSPHORUS-RICH SPENT CATALYSTS AS A FERTILIZER

ABSTRACT

Ferti-Val Inc., Ultramar Canada Ltd., and Agriculture and Agri-Food Canada teamed up recently to undertake a demonstration project of a technology to transform spent polymerization catalysts into fertilizer. This type of catalyst is classified as hazardous waste because it hydrolizes on contact with water, releasing phosphoric acid. The project's other aim was to fabricate trisodium phosphate (Na_3PO_4) from the same type of spent catalyst.

Employing wood ash and compost, the spent catalyst, in granular form, was transformed into an efficient and environmentally-safe phosphatic fertilizer. Testing of the fertilizer was conducted on plants in a greenhouse, where it demonstrated its effectiveness.

HIGHLIGHTS

- **Technology**
  - Reclamation of phosphorus-rich catalysts for use in agriculture
  - Production of an effective phosphatic fertilizer supplying plants with essential nutrients
  - Fabrication of trisodium phosphate from spent catalysts.
- **Environment**
  - Transformation of a hazardous waste into a useful product
  - Adding value to waste destined to landfill.
- **Cost**
  - Low-cost technique for adding value to a hazardous waste.

Saint-Laurent Vision 2000

Environment Canada Protection Québec Region

Environnement Canada Protection Région du Québec

FERTIVAL INC.

Ultramar

Canada Economic Development / Développement économique Canada

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

PROJECT OBJECTIVES

A. Verify the potential of phosphorus-rich spent catalysts for use as a fertilizer. Certain elements of the project were studied in depth in three greenhouse experiments:

   Experiment 1: Verify the effectiveness of a fertilizer composed of spent catalysts, compost and wood ash. This organic fertilizer, fabricated from urban and industrial waste, was compared to commercial mineral fertilizers.

   Experiment 2: The key objective was to assess the use of this material as a source of phosphorus in compost-derived humus. Spent catalysts could thus replace triple superphosphate in the preparation of humus.

   Experiment 3: Here, the objective was to measure the capacity of waste gravel to supply phosphorus to plants. The gravel, coated in spent catalyst, was incorporated into compost- and peat-based humus typically used in tree nurseries.

B. A second component of the project consisted of evaluating the possibility of fabricating trisodium phosphate from spent catalysts.

BACKGROUND

Ultramar Canada Ltd.'s Saint-Romuald refinery generates close to 750 tonnes of spent silicon-phosphate-based catalysts every year. This waste is currently classified as a hazardous waste because of its pH level (0.9). However, given its high phosphorus concentration, it is an excellent candidate for reclamation and use in agriculture. Prior to this time, the only disposal option available for this type of waste in Canada was secure landfilling.

Phosphorus is an element essential to plant growth. Whether to improve soil fertility or to maintain crops, the farming and horticultural sectors are always in need of phosphatic fertilizers.

The development of a fertilizer based on phosphorus-rich spent catalysts, compost and wood ash carries with it some advantages. On the one hand, it meets the needs of the agricultural sector for mineral fertilizer; on the other, it supplies organic mat-ter to the soil while recycling an industrial residue that is currently considered waste (phosphate residue and wood ash).

TECHNOLOGY

The fertilizer manufacturing technique consists of incorporating spent catalysts into wood ash and compost in proportions to yield the desired concentration of nutrients.

The neutralizing capacity of wood ash produces a final mixture with an adequate pH for this type of fertilizer.

A powder fertilizer is obtained that can then be spread with an agricultural lime spreader.

RESULTS

Description of the Residue

Ultramar's Saint-Romuald refinery is equipped with reactors to polymerize light petroleum by-products into products that can be used to make gasoline. The three-tiered catalysing systems used in the reactors are composed of catalysts—which are shaped like small cylindrical granules when new—placed on a bed of crushed stone and supported by wire mesh screens. After a certain period of time, these granules break up into fine particles that can hinder reactor operation. The spent catalysts, which are composed of more than 92% silicon orthophosphate and silicon pyrophosphate, must be replaced. Analyses indicate that spent catalysts are rich in phosphorus (49% P_2O_5) and that the level of contaminants they contain do not limit their use as a fertilizer.

Methodology

Experiment 1 was conducted on barley, soya and lettuce plants exposed to various doses of fertilizer. Experiments 2 and 3 were performed on barley, wheat and lettuce plants. The plants were grown to maturity in 1.5-L pots in a greenhouse at the Lennoxville Research Station of Agriculture and Agri-Food Canada.

Results

The results of experiment 1 indicated that the spent catalyst fertilizer produced yields of barley, soya and lettuce equivalent to or better than those obtained with triple superphosphate (see barley example in Table 1).

The second experiment showed the positive, if minimal, effects of spent catalyst on plant yield. The availability of the catalyst-derived phosphorus was also demonstrated (see Figure 1).

In the third experiment, the gravel contained in the spent catalyst was studied. In this case, the pH level of the substrate and the results of the phosphorus extracted using the Mehlich III solution indicated that the proportion of gravel in the humus was too high (5% in volume). Although negative effects were observed (low pH and reduced availability of potassium), the high dose of silicon phosphate adsorbed to the gravel did stimulate barley, wheat and lettuce growth. Moreover, the use of this gravel increased the phosphorus concentration in plant tissues.

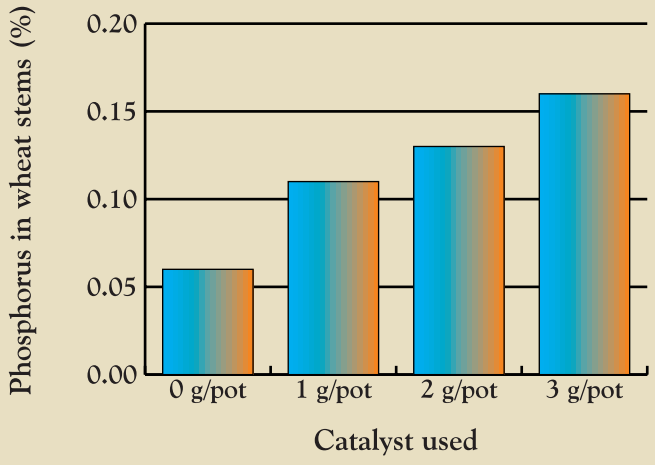
Conclusion

The three experiments conducted under this research project led to a better understanding of certain agronomic and horticultural characteristics of the spent catalyst. Taking into account both the positive and negative impacts assessed during this study, it is now possible to improve the composition of some types of humus and to produce an effective agricultural fertilizer from waste that had previously been sent to the landfill for disposal.

TABLE 1.
YIELD: BARLEY (EXPERIMENT 1)

Treatment	Dry weight of stems (g)	Dry weight of seeds (g)	Dry weight of roots (g)
Control (no phosphorus)	4.62	2.79	1.57
Triple superphosphate	5.30	3.26	2.04
Spent catalyst	5.36	3.25	2.20

FIGURE 1.
AVAILABILITY OF PHOSPHORUS (EXPERIMENT 2)



POTENTIAL AND LIMITATIONS

Potential

The three plant growth tests demonstrated that this type of spent catalyst contains phosphorus that is soluble and available for plant nutrition. The technology employed is efficient and quickly produces a competitively priced fertilizer.

The project's other broad component was to study the possibility of fabricating trisodium phosphate using spent catalysts as a base. Trisodium phosphate (Na_3PO_4) is used to manufacture detergents and cleaners. A process has been developed and a cost evaluation is under way which should reveal the commercial potential of the technology.

Limitations

Although the phosphorus derived from spent catalysts is soluble and available for uptake by plants, spreading difficulties limit the commercial potential of the final product. Indeed, due to its powdery texture, the product is impossible to spread using a conventional fertilizer spreader.

In addition, fertilizer fabricated from three basic inputs (spent catalysts, wood ash and compost) contains little nitrogen. Its use is therefore largely limited to crops with minimal nitrogen requirements.

INFORMATION

This technology data sheet is based on the results of a technology development project conducted by Ferti-Val Inc. in collaboration with Ultramar Canada Ltd. and Agriculture and Agri-Food Canada. The project was made possible through the technical and financial assistance of Environment Canada and the Canada Economic Development Agency for Quebec.

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St. Lawrence TECHNOLOGIES

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Canada