# Cyclorganic Fertilizer from Milinator Technologies: Canadian Export Idea

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AGR 1100: Section 105

Over the past century, the human population has increased by nearly 6 billion people (FAO, 2000). In order to support the growing population, agricultural practices have become increasingly intensified to produce a greater quantity of food from a relatively equal amount of land (FAO, 2000). The increased production can be contributed to many developments of the global agriculture industry, including the greater density cultivated livestock and the use of fertilizers (FAO, 2000). The high density of animals in modern livestock operations has created a concerning excess of animal waste and is predicted to double within the next thirty years (Zarebska et al., 2015; Ilea, 2009). Nearly 500,000 tones of manure are produced every day from livestock operations across Canada, which generates about 180 million tones of waste each year (Statistics Canada, 2006). Manure can serve as an abundant source of essential plant nutrients; however, the volume of manure generated by modern livestock operation is beyond a sustainable capacity (Zarebska et al., 2015).

It is critical that an alternative management practice for manure is implemented in order to minimize the repercussions that can be expected from the increasing production of manure (Alberta Agriculture, 2004). The livestock sector accounts for the greatest portion of air pollution that results from human industry, accounting for nearly 18% of all greenhouse gas emissions (Ilea, 2009). Manure from livestock operations has been estimated to contribute 68% of all nitrous oxide from human origin (Ilea, 2009). Many known environmental impacts have been determined to originate from the overabundance of raw manure (Alberta Agriculture, 2004). The storage and application of excess manure generates harmful greenhouse gases, such as methane and nitrous oxide (Alberta

Agriculture, 2004). For example, the common practice of storing unusable manure under anaerobic conditions results in a very low level of nitrogen (FAO, 2000). Anaerobic bacteria quickly degrade the nitrogen present in manure during storage and with minimal or no vegetation present to use the compounds released, the valuable source of nitrogen is lost to the environment (Milin, *Artists, Innovators & Visionaries Episode 11*). The loss of nitrogen is concerning because the composition of nutrients in the manure is altered, which causes further pollution. While the bacteria that develop in the manure during storage quickly alter the nitrogen compounds, the phosphate remains unchanged. Milin explains that farmers apply an excess of manure to accommodate for the low levels of nitrogen and as a result apply a concentration of phosphorous beyond the requirement of crops. Certain management techniques have been developed to reduce emissions from stored manure (Alberta Agriculture, 2004). However, no solution has been implemented that completely eliminates the air and water pollution from animal waste. The nutrient content of manure is generally not sufficient for modern agriculture to generate the necessary yields. Therefore, fertilizer is understood to be a necessary input for efficient agricultural production (FAO, 2000). Fertilizers, either from a natural or chemical source, allow farmers to maintain intensified production without depleting the land (FAO, 2000). As the Earth is no longer able to naturally support the quantity of food required by the dense human population, chemical fertilizers are commonly used (Smil, 2001).

The development of synthetic fertilizers has allowed for a greater increase in the productivity of agricultural land. Global agricultural production relies on chemical fertilizers to feed an estimated 40 to 60% of all food products (Zarebska et al., 2015). Smil (2001) suggests that the Haber-Bosch creation of synthetic nitrogen fertilizer can be understood to have allowed the increase in production that was necessary to support growing population. Today, we rely on the Haber-Bosch process to supply approximately half of all synthetic nitrogen that is required to meet production demand (Smil, 2001). The Food and Agriculture Organization of the United Nations estimated that approximately 40% of protein consumed around the world in the mid-90s originated from nitrogen synthesized by the Haber-Bosch process, which uses atmospheric nitrogen and natural gas (FAO, 2000).

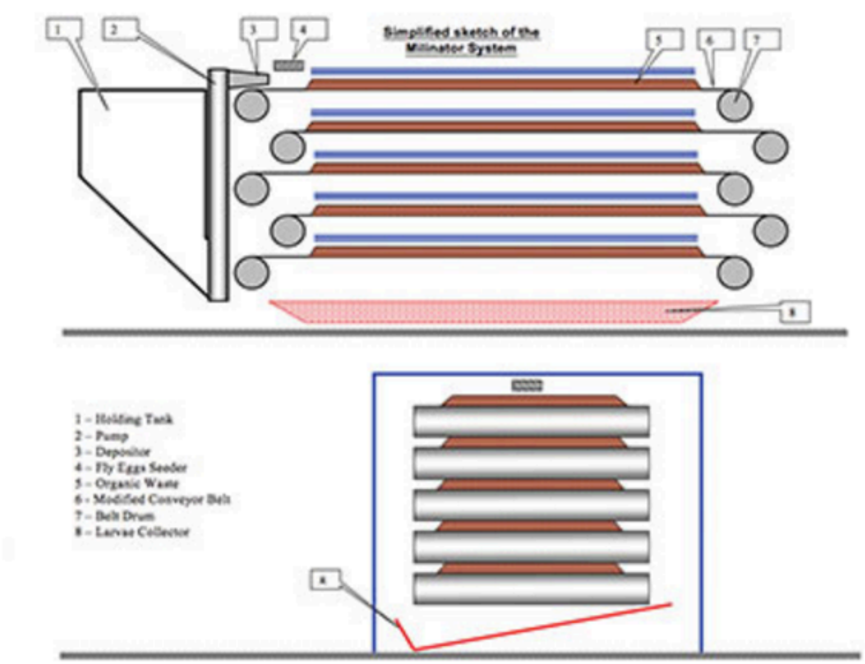
The global population is expected to rise beyond 9 billion by the year 2050, which will require a further increase in the quantity of food produced from agricultural land (Zarebska et al., 2015; FAO, 2015). Considering the modern dependence on fertilizer to meet production demand, fertilizer use will have to increase to sustain a greater quantity of food returned from production (FAO, 2015). Shaviv and Mikkelsen (1993) estimate that half of all nutrients supplied from synthetic fertilizer are lost to the surrounding environment as ammonia, nitrous oxide and other nitrogen compounds. The significant leaching of nutrients is polluting the land in the form of water and air pollution (Zarebska et al., 2015). Excess nitrate that escapes from fertilizer has collected in soil, groundwater reservoirs and bodies of water surrounding cropland (Savci, 2012). Nitrate pollution is of great concern due to the severe health implications of water containing an excess of the compound (Sahviv and Mikkelsen, 1993). To maximize the low efficiency of current fertilizer sources, the agriculture industry should increase the use of fertilizer available in a slow-release form, where nutrients are steadily supplied to plants over time (Sahviv and Mikkelsen, 1993). Despite the proven advantages to supplying nutrients to crops in a controlled manner, the proportion of controlled-release fertilizer compared to fast acting sources is minimal (Sahviv and Mikkelsen, 1993). The use of slow-release fertilizer is mainly restricted to becoming a common practice due to the high cost (Sahviv and Mikkelsen, 1993).

It is estimated that around 90% of the increased food production required for the rapidly growing population must be generated from agricultural land currently under production (FAO, 2000). Current management practices regarding the surplus of manure and the use of fertilizers has contributed to environmental damage that could reverse the associated benefits of supplying extra nutrients. Fertilizer development around the world has allowed a successful increase in crop yields but has caused environmental damage. Therefore, it is critical that a sustainable and efficient source of fertilizer that will not cause further harm be developed for global agricultural use.

Ivan Milin is a professional engineer from Toronto, Ontario who has developed a unique technology called the Milinator process, which recycles organic waste products to generate a highly effective fertilizer, called Cyclorganic (Ecospace Engineering, 2013). Cyclorganic is a slow-release fertilizer produced by Milinator Technologies Inc. in Toronto, Ontario, using only natural ingredients. The concept behind the Milinator technology originated from an idea developed by the Russian Space Program that would allow humans to survive interplanetary space travel (Ecospace Engineering, 2013). The Russian scientists designed a system that would recycle all waste products generated within the enclosed environment of a spaceship (Milin, *Artists, Innovators & Visionaries, Ep. 10*). The technology was capable of processing a small amount of waste, including leftover food and fecal matter, into a nutrient rich substance. The recycled product would serve as a feed source for birds and crops that would be cultivated within the ship, which would in turn feed the astronauts (Milin, *Artists, Innovators & Visionaries, Ep. 10*).

The Milinator technology is an expansion of the Russian recycling process and has been adapted to facilitate industrial volumes of manure (Milin, *Artists, Innovators & Visionaries, Ep. 10*). The original Russian recycling system was designed to circulate air down the length of the belt, which restricted the maximum area that could be processed at once. Milin made a simple alteration to the original process by changing the direction the air would circulate. Beyond a certain length, the warm air that is required to circulate through the processing machine would cool down to significantly to allow proper recycling. The Milinator technology can support any volume of manure because the air circulates across the width of the belt instead of length-wise. Milinator technology can accommodate any volume of manure by increasing the length of each conveyer belt. Milinator rapidly recycles raw manure in less than a week using the natural larval activity of the common housefly, *Musca domestica* L. Strictly using the metabolism of fly larvae, fresh manure is degraded over a short period to generate a fertilizer called Cyclorganic. The fly eggs are collected from a population of adults that have been domesticated and contained for the Milinator technology. On the first day of the Milinator process, the eggs are applied to the manure as it is distributed evenly along the first of five conveyer belts (*Figure 1)*. The manure will progressively move along each layer of the conveyer belt, occupying one level per day over a period of 5 days (*Figure 1*). As the manure travels through the Milinator machine, warm air is circulated across the conveyer belt. By the end of the second day, the larvae have begun to rapidly digest the nutrients within the manure as well as any bacteria that may have developed during the first day (Milin, *Artists, Innovators & Visionaries, Ep. 10*).

The demonstrative video from Ivan Milin shows the consistency of manure being further refined by the larvae each day (Milin, *Space Travel*). By the end of the third day, the larvae have grown to nearly their full size and the manure has been processed into a much drier and finer texture (Milin, *Space Travel*). Near the end of the process the larvae have grown to approximately 300 times their original weight and contain a high concentration of protein (EcoSpace Engineering, 2013).




Courtesy of Ivan Milin. Retrieved from: https://www.canadianpoultrymag.com/business-policy/farm-business/rocket-man-14491.

Figure 1: Schematic drawing of the side (top) and front view (bottom) of the prototype Milinator unit designed and engineered by Ivan Milin and Walinga Inc., respectively. The front view of the machine illustrates the ramp that will deposit the larvae in a separate container.

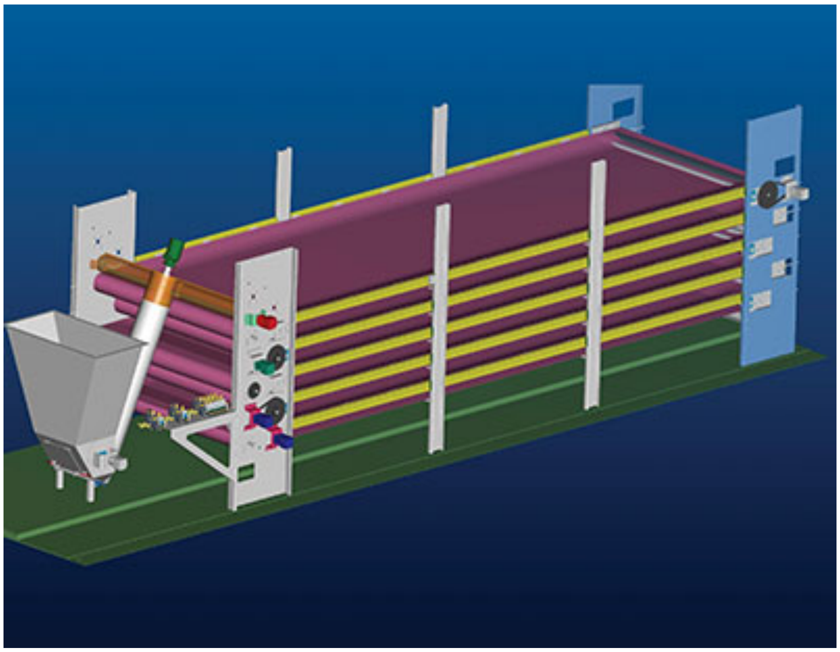
The final products of the Milinator technology include the Cyclorganic fertilizer as well as a protein-rich source of dried *M. domestica* larvae. The fly larvae instinctually search for a cooler environment to pupate (Milin, *Artists, Innovators & Visionaries, Ep. 10*). They naturally separate themselves from the finished product, as they will move out of the warm manure at the end of the conveyer and fall into a separate container designed to collect the larvae (*Figure 1*) (Milin, *Artists, Innovators & Visionaries, Ep. 10*).

The composition of the final Cyclorganic product is displayed in *Table 1*. The proportion of nitrogen is much greater in Cyclorganic than manure that has been stored under anaerobic conditions (Milin, *Artists, Innovators & Visionaries, Ep. 11*). As mentioned earlier, a large quantity of nutrients are released from manure during storage and improper application. Compared to the approximate analysis of 1% of nitrogen that is found in anaerobic digested manure, the Milinator process results in 5% total nitrogen, which will eliminate a major portion of greenhouse gas emissions released from the livestock industry (Milin, *Artists, Innovators & Visionaries, Ep. 11*; Ilea, 2009). The higher concentration of nitrogen in Cyclorganic compared to stored manure (Milin, *Artists, Innovators & Visionaries, Ep. 10*). Cyclorganic is also a good source of calcium, which accounts for around 6% of the overall composition. A significant portion, around two thirds (66%), of Cyclorganic is organic matter. Milin has been producing his fertilizer product using Canadian poultry manure, specifically from egg laying hens. However, the Milinator process can be applied to any source of waste, including food, the dead flies that result from captivity or other livestock manure (Milin, *Artists, Innovators & Visionaries, Ep. 11)*. Cyclorganic is a superior source of organic nutrients as a result of the biological activity of the *M. domestica* larvae (EcoSpace Engineering, 2013). The metabolism of the larvae creates other beneficial molecules within the soil, such as enzymes and vitamins, which are advantageous for plant development (EcoSpace Engineering, 2013).

Table 1: Guaranteed minimum analysis of the partial composition of Cyclorganic fertilizer from Milinator Technologies Inc.

| **Component** | **Proportion (%)** |
|---|---|
| Total Nitrogen | 5 |
| Phosphorous | 1.34 |
| Potassium | 1.67 |
| Calcium | 6 |
| Magnesium | 0.4 |
| Sulfur | 0.35 |
| Organic matter | 66 |

Milinator Technologies Inc. offers a unique solution for manure management as it is the only development that can recycle waste without generating any pollution (EcoSpace Engineering, 2013). In fact, manufacturing a single kilogram of Cyclorganic fertilizer is understood to eliminate pollution equal to 60 litres of carbon dioxide and 12 litres of ammonia (EcoSpace Engineering, 2013). Developing a market for Cyclorganic fertilizer in Nepal could benefit the Canadian economy and environment in many ways. A number of Canadian companies have been involved in the growth of Milinator Technologies Inc (EcoSpace Engineering, 2013). EcoSpace Engineering Inc., in Toronto, Ontario, in collaboration with Milinator Technologies Inc., owns the rights to the technology. The Ontario Ministry of Agriculture has funded the development of Milin's recycling system. Walinga Inc. is an engineering firm in Guelph, ON that has built the prototype Milinator unit from Milin's design, illustrated below in *Figure* 2.



Retrieved from: https://www.canadianpoultrymag.com/business-policy/farm-business/rocket-man-14491. Courtesy of Walinga Inc.

Figure 2: A 3-D drawing of Milinator Technologies prototype recycling unit, designed by Milin and engineered by Waling Inc., with a manure pump and 5 conveyer belts, one for each day of processing.

Since 2010, The University of Guelph, also in Ontario, has been operating a 200 kg prototype unit at a research station through the university. The Arkell Research Station and the Animal Biosciences department at the University of Guelph have contributed to the research of the technology and the effects of applying Cyclorganic in crop fields (EcoSpace Engineering, 2013). The Milinator technology is still being studied and refined, however, creating an additional market overseas would contribute to the growth of the technology through further research in a new environment. The labor force required for the manufacturing of Cyclorganic would create additional jobs in primary agriculture in rural parts of Canada (Milin, *Space Travel*). For example, Milin plans to incorporate Milinator processing plants beside poultry operations throughout Canada to create the option of on-site processing facilities that would allow raw manure to be recycled instantly into a safe product. Growth of Milinator Technologies Inc. would benefit Canada's environment by removing a significant source of pollution and creating a fertilizer with minimal ecological impact. Immediate processing of animal waste using the Milinator technique could eliminate all sources of pollution associated with the storage and application of manure (Milin, *Space Travel)*. If the Milinator technology could be implemented as a common management practice, Canadian farmers would have access to a beneficial organic fertilizer for domestic use. Beyond the cost of the equipment and labor required for manufacturing the cost to produce Cyclorganic is minimal (Milin, *Space Travel)*. The larvae that result from the Milinator process could be used as a protein supplement for poultry feed (Milin, *Space Travel)*. Excess Cyclorganic produced from Canadian poultry farms could be sold for commercial or household use.

For additional information, the contact information for both EcoSpace Engineering/Milinator Technologies Inc. and Walinga Inc. are provided below.

| **Distributed by:** | **Prototype Engineer:** |
|---|---|
| EcoSpace Engineering | Walinga Inc. |
| 210 Elmherst Drive | 5656 Hwy. 6 North/ |
| Toronto, ON, Canada | Regional Road #5 |
| M9W 2L6 | Guelph, ON, Canada |
| Phone: 416-742-6501 | N1H 6J2 |
| www.ecospace-eng.com | www.walinga.com |
| www.cyclorganic.com | walinga@walinga.com |

Nepal is a small developing country located between India and China and is one of the most densely populated countries in the world (Smith, 1991). In Nepal, approximately 29 million people live within an area of 147,181 square kilometers. In comparison, Canada has 6 million more people than within approximately 62 times more land (World Fact Book: Canada, 2016). The agriculture industry employs around 3 quarters of the Nepalese population and contributes nearly 40% of the total GDP, making it the most profitable industry in Nepal. (World Fact Book: Nepal, 2016) However, Nepal *remains among the least developed countries* with more than half of the population considered below the poverty line, as of 2004 (UNICEF: Malnutrition, 2016; Devkota and Upadhyay, 2013). Slightly below one third of the land in Nepal is suitable for agricultural production (Figure 1) and is further divided among arable land, pastures and permanent crops (Figure 2) (World Fact Book: Nepal, 2016).

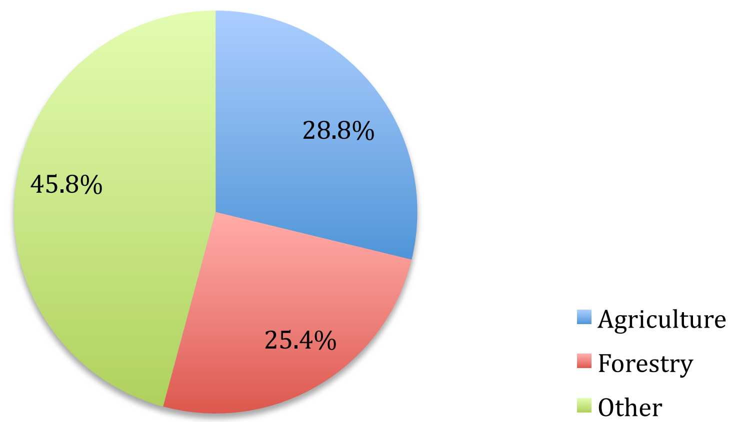



Figure 1: Land use in Nepal.

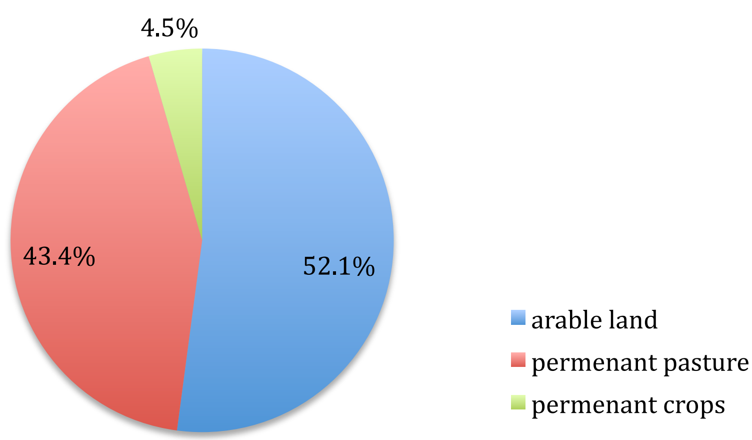
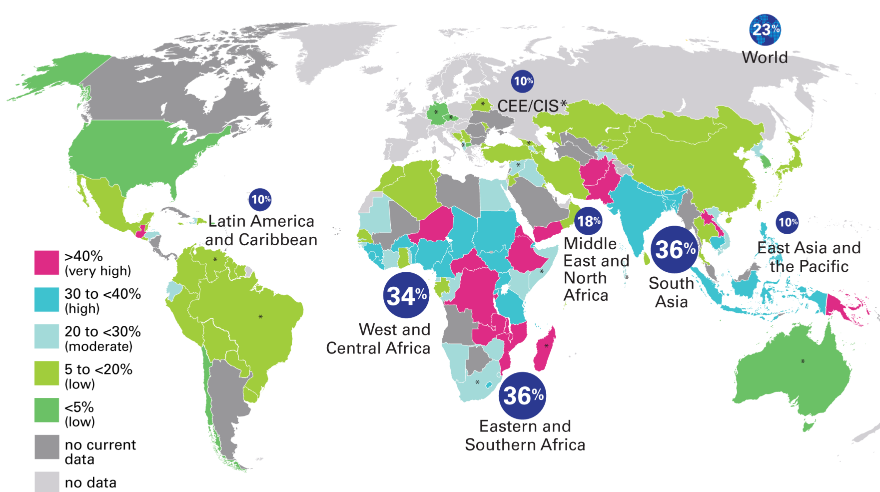



Figure 2: Division of agricultural land in Nepal among arable, pasture, and permenant crop land.

Nepal can generally be divided into three geographical areas: The terai, hill and mountainous regions. The terai region refers to the plains of Nepal, which is located in the south and borders India (Devokta and Upadhyay, 2013). A significant portion of crop growth is restricted to the mid-hill and plains regions of Nepal as 34% of Nepal's total land area consists of a relatively unproductive mountainous region (Devokta and Upadhyay, 2013). The plains, or terai region, in the south and the mid-hill region have a rate of production two times greater than the mountainous terrain, with the greatest quantity of food cultivated in the hills of Nepal. The limited area of productive land in Nepal as well as the dense population is understood to restrict further agricultural development (Devokta and Upadhyay, 2013). As a result, the prevalence of malnutrition in Nepal is very high, with a proportion between 30-40% of the population reported as malnourished, as illustrated in *Figure 3* (UNICEF: **Malnutrition, 2016**). Devokta and Upadhyay (2013) state that nearly three quarters of Nepalese families have less than one hectare of productive land. The minimal amount of productive land available to Nepal's dense population emphasizes the requirement for improved agricultural practices.




Retrieved from: http://data.unicef.org/topic/nutrition/malnutrition/

Figure 3: Map of global malnutrition demonstrating a proportion of nearly 40% of South Asia experiencing malnutrition.

Agricultural production in Nepal is far lower than surrounding nations in South Asia (Devkota and Upadhyay, 2013). Bohle and Adhikari (1998) state that a significant portion of Nepal's population does not have access to an adequate amount of food due to low agriculture production. Nepal's need for intensified production, Nepal has not only failed to continue to increase yields, but the output of certain crops is actually decreasing (Devkota and Upadhyay, 2013). Nepal's weak productivity can be attributed to the minimal use of fertilizer, which also lags behind other developing countries (Shrestha, 2010; FAO, 2000). Fertilizer is deemed a critical input for sustained crop production where the output required is beyond the capacity of the natural land (Smil, 2001). While the volume of fertilizers used in Nepal has been increasing, overall use remains below an adequate value (Shrestha, 2010). Nepal's government has attempted to subsidize fertilizer to encourage local farmers to incorporate a greater amount of nutrients into production. However, the government has not been successful in supplying farmers with the required quality and quantity of fertilizer (Shrestha, 2010).

Nepal is currently experiencing a similar issue of soil degradation, as the use of fertilizer has not increased at a sufficient rate (personal communication: Tejendra Chapagain, 2016). Therefore, it is vital that Nepal has access to a sufficient amount of fertilizer in order to increase and maintain the concentration of nutrients in their soil to avoid further land degradation (FAO, 2000). It has been demonstrated that improving the low rates of agricultural productivity in developing nations can help to reduce the severity of poverty (Devokta and Upadhyay, 2013). Therefore, addressing the need for a substantial increase in crop production is necessary to improve more than just agriculture issues, but social and economic issues as well (Devokta and Upadhyay, 2013). The fertilizer currently available to Nepalese farmers is often of an unreliable quality and is highly expensive (Shrestha, 2010). Nepal must resort to importing a significant portion of their fertilizer from India, as it is often lower in price (Shrestha, 2010). Nepal would benefit from the use of Cyclorganic fertilizer as it would help increase the efficiency of the land output without causing harm to the environment (EcoSpace Engineering, 2013). The short-term advantages of Cyclorganic include the increase in crop yields that is known to result from its application (EcoSpace Engineering, 2013). With long-term use, the high proportion of organic matter present in the fertilizer will improve the soil quality of Nepal's land (FAO, 2000). Organic sources of nutrients, including animal waste, can often lack one or more of the essential nutrients needed to create the optimal concentration of nutrition that is necessary for plant development (Milin, *Artists, Innovators & Visionaries Episode 11*). Under the same storage conditions, the phosphorous composition in manure remains unaltered. The disproportionate recycling of nitrogen and phosphorous under anaerobic conditions creates an issue when the stored product is applied to the land. To accommodate for the reduced quantity of nitrogen available in the manure, a greater volume is used. While the nitrogen requirements for crop production may be meet, the resulting level of phosphorous is far beyond the nutritional requirement of plants and may become toxic. The nutrient content of Cyclorganic is naturally balanced for optimal plant development. A portion of nutrients is released from the fertilizer instantly when exposed to the soil and therefore improved plant growth will be noticeable shortly after application. The remaining nutrient content of Cyclorganic is released to the soil by microbial activity to match the requirement of the crops (*Artists, Innovators & Visionaries Episode 11)*.

The use of a controlled-release fertilizer such as Cyclorganic would increase the efficiency of nutrients without the risk of contaminating groundwater resources and surrounding bodies of water (Shaviv and Mikkelsen, 1993). Another benefit of Cyclorganic being a source of slowly released nutrients is that a single application can generally suffice an entire crop season with a significantly improved output (*Artists, Innovators & Visionaries Episode 11)*. The composition of Cyclorganic makes it a complete source of all essential nutrients, and therefore could be used without additional fertilizers, and therefore avoid additional costs (*Artists, Innovators & Visionaries Episode 11)*. The organic matter from Cyclorganic would improve the quality of Nepal's land, which is currently experiencing soil degradation, and allow for a less expensive and more effective method of fertilization (FAO, 2000; personal communication: Tejendra Chapagain, 2016).

Cyclorganic is a superior choice of fertilizer compared to other Canadian organic products because of the sustainability of the Milinator process. Glacial Rock Dust from Gaia Green Earth is also a slow release fertilizer (Gaia Green: Products, 2016). Glacial Rock Dust however, is made from glaciers, which will not be regenerated (Gaia Green: Products, 2016). The ingredients required to produce Cyclorganic, manure and *M. domestica* eggs, are both naturally replenished as by-products from livestock production. Cyclorganic fertilizer could be shipped from Ontario to Halifax by train. From the east coast of Canada, A1 Freight Forwarding, a Canadian company, would ship a single crate of Cyclorganic on an Ocean Carrier to Nepal (A1 Freight Forwarding, 2016). At the current rate of Cyclorganic production in Canada it would be too costly to ship the manufactured fertilizer to Nepal (personal communication: Ivan Milin, 2016)**.** The retail cost is currently very high, around $30 for a 400-gram bag (EcoSpace Engineering, 2013). It is recommended to use 30g of Cyclorganic for a square foot of land, mixing with the top 4 inches of topsoil (EcoSpace Engineering, 2013). To supply an average size farm in Nepal with an adequate amount of Cyclorganic would not be feasible due to unrealistic importing and production costs. A farm with 0.04 hectares of land would require just over 280 pounds of Cyclorganic fertilizer. In addition, the cost associated with transporting Cyclorganic from Canada to Nepal is unrealistic considering the high costs. Further research should be done to consider the possibility of incorporating the Milinator technology in Nepal to all on-site production of Cyclorganic. Domestic production of the fertilizer would eliminate transportation costs. Milin (2013) stated that the initial processing unit was built for under $500 (Milin, *Artists, Innovators & Visionaries Episode 11*). The process would require electricity just to circulate air throughout the machine.

There is potential for the Milinator Technology to further improve conditions in Nepal beyond agricultural use (EcoSpace Engineering, 2013). The second product of the Milinator technology is the protein-rich larvae and pupae that are collected at the end of the process. It was mentioned previously that the larvae are collected on the final day of processing with a weight 300 times greater than their input weight. The fly larvae can be dried and used as a feed supplement for poultry birds, which would also promote the production of Cyclorganic in Nepal itself because the larvae are very rich in protein and can be used as a supplement for poultry feed as a cost-cutting livestock food source (EcoSpace Engineering, 2013). Currently, the Milinator Technology has only been applied to process poultry manure. However, Milin (2013) stated that the recycling capabilities of *M. domestica* larvae could be applied to any form of organic waste. Developing the Milinator Technology in Nepal could potentially facilitate human waste as the metabolism of the fly larvae has been proven to degrade bacteria (EcoSpace Engineering, 2013).

The possibility of the Milinator technology being introduced to Nepal would enable domestic production of an efficient, balanced fertilizer required for the necessary increase in crop yields (EcoSpace Engineering, 2013). Nepal has a rapidly growing poultry industry with, as of 2007, over 8 million egg laying birds that would generate the manure required to manufacture Cyclorganic (Acharya and Kaphle, 2014). Similarly, incorporating the manure recycling process in Nepal would remove a portion of the waste products generated by poultry farms (Ecospace Engineering, 2013). While Milin has been developing his technology specifically using poultry manure, any form of organic waste could be recycled by the Milinator technique (Milin, *Artists, Innovators & Visionaries Ep. 11*).

The Cyclorganic fertilizer created by Milinator Technologies Inc. has the potential to provide many benefits to the agriculture industry of Nepal. However, at the current state of production, the export of Cyclorganic fertilizer from Canada to Nepal has proven to be too costly to truly benefit the country. Transportation costs would restrict the export of Cyclorganic from Canada to Nepal. Nepal is in need of the many benefits the fertilizer and recycling technology could provide. Therefore, further research should be done to develop the Milinator recycling system in Nepal to process sources of organic waste**.** It is important that the development of Milinator Technologies is successful as it is the only system that has proven to eliminate sources of pollution associated with the improper management of manure and the required volume of fertilizers.

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