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Minimizing Fraud in the Carbon Offset Market Using Blockchain Technologies

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ABSTRACT

Fraud in the Environmental Benefit Credit (EBC) markets is pervasive. To make matters worse, the cost of creating EBCs is often higher than the market price. Consequently, a method to create, validate, and verify EBCs and their relevance is needed to mitigate fraud.

The EBC market has focused on geologic (fossil fuel) CO_2 sequestration projects that are often over budget and behind schedule and has failed to capture the "lowest hanging fruit" EBCs–terrestrial sequestration via the agricultural industry. This project reviews a methodology to attain possibly the least costly EBCs by tracking the reduction of inputs required to grow crops. The use of bio-stimulant products, such as humate, allows a farmer to use less nitrogen without adversely affecting crop yield. Using less nitrogen qualifies for EBCs by reducing nitrous oxide emissions and nitrate runoff from a farmer's field. A blockchain that tracks the bio-stimulant material from source to application provides a link between a tangible (bio-stimulant commodity) and the associated intangible (EBCs) assets. Covert insertion of taggants in the bio-stimulant products creates a unique barcode that allows a product to be digitally tracked from beginning to end. This process (blockchain technology) is so robust, logical, and transparent that it will enhance the value of the associated EBCs by mitigating fraud. It provides a real time method for monetizing the benefits of the material.

Substantial amounts of energy are required to produce, transport, and distribute agricultural inputs including fertilizer and water. Intelligent optimization of the use of agricultural inputs can drive meaningful cost savings. Tagging and verification of product application provides a valuable understanding of the dynamics in the water/food energy nexus, a major food security and sustainability issue. As technology in agriculture evolves so to must methods to verify the Enterprise Resource Planning (ERP) potential of innovative solutions. The technology reviewed provides the ability to combine blockchain and taggants ("taggant blockchains") as the engine by which to (1) mitigate fraudulent carbon credits; (2) improve food chain security, and (3) monitor and manage sustainability.

The verification of product quality and application is a requirement to validate benefits. Recent upgrades to humic and fulvic quality protocols known as ISO CD 19822 TC134 offers an analytical procedure. This work has been assisted by the Humic Products Trade Association and International Humic Substance Society.

In addition, providing proof of application of these products and verification of the correct application of prescriptive humic and bio-stimulant products is required. Individual sources of humate have unique and verifiable characteristics. Additionally, methods for prescription of site-specific agricultural inputs in agricultural fields are available. (See US Patents 734867B2, US 90658633B2.) Finally, a method to assure application rate is required through the use of taggants. Sensors using organic solid to liquid phase change nanoparticles of various types and melting temperatures added to the naturally occurring materials provide a barcode. Over 100 types of nanoparticles exist ensuring numerous possible barcodes to reduce industry fraud.

Taggant materials can be collected from soil samples of plant material to validate a blockchain of humic, fulvic and other soil amendment products. Other non-organic materials are also available as taggants; however, the organic tags are biodegradable and safe in the environment allowing for use during differing application timeliness.

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ACRONYMS AND DEFINITIONS

Abbreviation	Definition
ACR	American Carbon Registry
BAU	business as usual
COT	chain of title
DOE	Department of Energy
EBC	Environmental Benefit Credit
ERP	Enterprise Resource Planning
EPRI	Electric Power Research Institute
GHG	greenhouse gas
ID	identification
LCA	life cycle approach
MSU	Michigan State University
SMC	soil microbial communities
SNL	Sandia National Laboratories
SOM	soil organic matter
SOC	soil organic carbon
USDA	United States Department of Agriculture
VCS	Verified Carbon Standard

1. INTRODUCTION

Nearly all efforts toward lowering greenhouse gases (GHG) to date have focused on fossil fuel reduction while neglecting the "lowest hanging fruit"–land and water use. Relatively new research indicates that improvements in agricultural management and land reclamation practices could significantly reduce GHG emissions. More specifically, the overuse of synthetic nitrogen (N) fertilizers are limiting the soil and biotic pool's ability to sequester carbon and nitrogen.

University of Illinois researchers led by professors Richard Mulvaney, Saeed Khan, and Tim Ellsworth argue that "synthetic nitrogen use creates a kind of treadmill effect." The researchers also state:

> As organic matter dissipates, soil's ability to store organic nitrogen declines. A large amount of nitrogen then leaches away, fouling ground water in the form of nitrates, and entering the atmosphere as nitrous oxide (N_2O), a greenhouse gas with some 300 times the heat-trapping power of carbon dioxide. In turn, with its ability to store organic nitrogen compromised, only one thing can help heavily fertilized farmland keep cranking out monster yields: more additions of synthetic N. The loss of organic matter has other ill effects, the researchers say. Injured soil becomes prone to compaction, which makes it vulnerable to runoff and erosion and limits the growth of stabilizing plant roots. Worse yet, soil has a harder time holding water, making it ever more reliant on irrigation. As water becomes scarcer, this consequence of widespread synthetic N use will become more and more challenging. [1]

One of the most sensible, low cost methods for attaining GHG emission offsets in the carbon credit markets is through the agricultural arena, which also includes efficient applications of water. Replacing a portion of the synthetic N applied to crops with bio-stimulant products such as humate has been shown to improve soil by increasing soil organic matter (SOM). Increasing SOM improves a soil's ability to sequester carbon, lowers the amount of synthetic N fertilizer and water required by crops, which decreases N_2O emissions and nitrate runoff from a farmer's field.

A variety of industries can use biostimulant substances such as humate to attain carbon, nitrogen and/or water offsets; however, linking this tangible asset–"biostimulant" to the corresponding "intangible" offsets is critical for broad-based acceptance. An ideal way to accomplish this is by using "blockchain technology." Blockchain technology will effectively link data associated with the humate (or other commodity) from the mine site, to the processing location, to the application site and then follow the crop to a final end user. This is a life cycle approach (LCA) using a chain of title (COT).

Unlike traditional tangible commodities, the advent of "carbon," "nitrogen," and "water" credits or Environmental Benefit Credits (EBCs) has created a new international commodity that is intangible. Like any commodity market, every asset (offset) must be identifiable and trackable to ensure market integrity. The carbon trading market is one of the world's fastest growing commodities market [11] as evidenced by the fact that most Fortune 1000 companies have detailed Sustainability Reports. Considering the speed at which these new "intangible asset" markets, especially EBC trading, are growing the potential for fraud is high; therefore implementation of a digital ledger that cannot be unilaterally altered will reduce the chance of fraud in the markets. This process is known as "Smart Contracting." Additionally, "sustainability" is a term numerous companies and other entities have adopted but verification of sustainability protocols is mandatory to connect the term with the appropriate steps validating sustainable protocols. It is a matter of food safety and security. The invention under review is a method to provide these requirements.

1.1. Examples of Fraud

In May 2016, a former Deutsche Bank employee was sentenced to 3 years in jail for his part in a scheme trading carbon emission permits designed to curb global warming but used to fraudulently collect tens of millions of euros of sales tax.

Handing down suspended jail sentences to five other former Deutsche bankers also involved, Judge Martin Bach criticized Germany's largest bank, saying the "failure of all security mechanisms" had allowed the fraud.

Interpol, in its June 2013 report titled "Guide to Carbon Trading Crime," identified five areas where fraud generally occurs within the carbon markets:

1. fraudulent manipulation of measurements to claim more carbon credits from a project than were actually obtained;
2. sale of carbon credits that either do not exist or belong to someone else;
3. false or misleading claims with respect to the environmental or financial benefits of carbon market investments;
4. exploitation of weak regulations in the carbon market to commit financial crimes, such as money laundering, securities fraud or tax fraud; and
5. computer hacking/phishing to steal carbon credits and theft of personal information. [11]

An LCA utilizing a blockchain technology would provide the security necessary to eliminate the fraud opportunities that Interpol describes above. More specifically, a COT similar to the environmental industry methodology for tracking hazardous waste (cradle to grave) and water samples (chain-of-custody) will minimize the potential for fraud related to EBCs derived from the use of biostimulant materials.

2. BACKGROUND

Since the Industrial Revolution there has been a significant atmospheric increase in the concentration of GHGs leading to an increase in the average global surface temperature of 0.6°C since the late 19th century. The current warming rate of 0.17°C/decade is greater than the critical rate of 0.1°C/decade where it is thought that ecosystems cannot adjust. [4]

In essence, anthropogenic changes have moved elements such as carbon and nitrogen between the global pools. Possibly more than any other biologically important element, the global nitrogen cycle has been perturbed by anthropogenic activities. The rate of industrial N fixation now approximately equals the natural rate, resulting in a two to threefold increase in the total inventory of fixed N on the surface of the Earth through agricultural fertilizer applications. [6] In its inert form, N is harmless and abundant (78% of earth's atmosphere), but the addition of synthetic N-based fertilizers has the unintended consequence of diminishing soil C and disrupting the beneficial associations between plants and the soil microbial communities (SMC). [10] Cropping practices and the use of N fertilizers are estimated to cause 78% of the total soil N_2O emissions in the United States [7], promoting emissions having a greenhouse warming potential 310 times that of CO_2. [8, 9]

For years, the conventional thinking has been that application of synthetic N fertilizers improved soil C while producing more crops. Research data from the Morrow Plots in Illinois, the oldest research plots in the country, indicate a decline in soil C from the use of synthetic N fertilization. The intensive use of N fertilizers in modern agriculture and land reclamation is increasing C and N in the atmospheric pool, i.e., contributing to global GHG accumulation.

There are five principal global C pools (Figure 1). The total soil C pool is four times the biotic (trees, etc.) pool and about three times the atmospheric pool. [3] All these pools are inter-connected, and elements circulate among them. The units used in Figure 1 are Pg which represents Petagram. One Petagram is equal to just about 2,200,000,000,000 (or 2.2 trillion) pounds!

Despite a strong inter-dependence between climate and soil quality, the role of SOC dynamics on historic increase in atmospheric CO_2, and its strategic importance in decreasing the future rate of increase of atmospheric CO_2 have only recently been recognized.

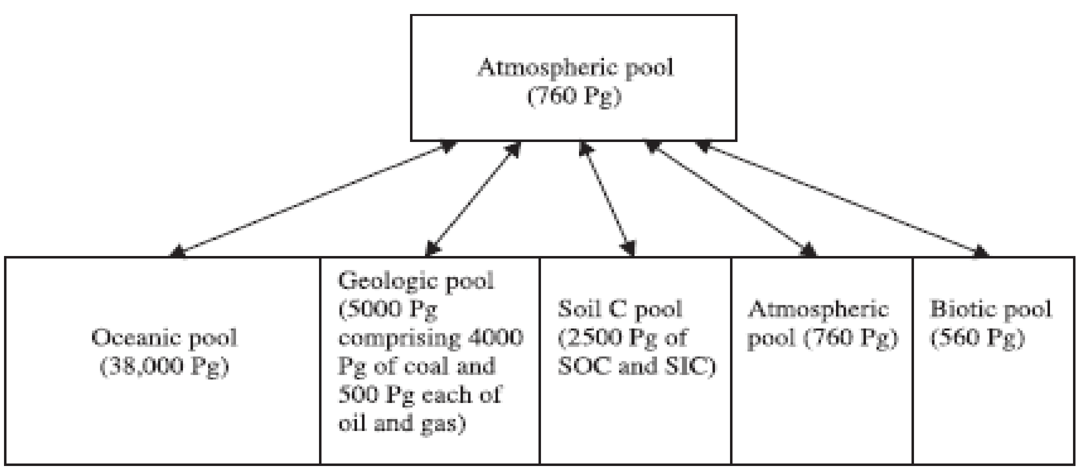

Figure 1. Principal global carbon pools

3. WHAT IS AN ENVIRONMENTAL BENEFIT CREDIT?

An Environmental Benefit Credit (EBC) is an intangible asset obtained by reducing known GHG emissions or water use. The most recognizable credit is Carbon offsets; however, there are other potential credits that can be gained by reducing N_2O emissions, or by saving water. The most common credit—carbon offsets—are credits traded on carbon markets that represent GHG emission reductions generated from a change in management practice. In agriculture, the potential exists for obtaining EBCs in two ways: (1) fixing carbon in agricultural soil, and (2) by lowering nitrous oxide emissions from a farmer's field by reducing the amount of synthetic nitrogen used. Electric Power Research Institute (EPRI) and Michigan State University (MSU) jointly developed and validated a comprehensive methodology for farmers to capture GHG emission offsets–particularly nitrous oxide. The EPRI-MSU N_2O offset protocol is scientifically robust, applicable to a wide range of climates, soils, and crops, transparent, and is based upon a standardized approach to additionality and baselines.

The protocol however has not been widely adopted by farmers because it is not very user friendly. Biostimulants such as humic and fulvic products offer a robust solution based broadly on the EPRI-MSU protocol. Two benefits are derived from replacing a portion of synthetic nitrogen fertilizer with a prescriptive dose of humic and fulvic. First, a physical reduction in use of nitrogen and second the input of humic and fulvic materials improving SOC and maintaining crop quality and quantity.

3.1. Carbon Markets

Compliance and voluntary carbon markets exist in the United States and globally. Compliance markets comprise the trading of carbon credits and offsetting of carbon emissions by countries that are legally bound to comply with the Kyoto Protocol. Outside of these markets, carbon offset credits can be traded in the voluntary carbon market by any citizen or institution looking to offset their greenhouse gas emissions. [2] Within the carbon markets the responsibility falls on individual companies to trade carbon credits with each other. The intent is to ensure the free market (private sector) determines the least costly emission cuts.

3.1.1. Other Environmental Benefit Markets

Agricultural input prices and crop prices are highly correlated. This leads to volatile price swings in agricultural inputs and crop price markets. Biostimulant and carbon offset markets are much less correlated to traditional fertilizer inputs. The use of a biostimulant product such as humate effectively acts as a hedge to price volatility of crop inputs. Additional revenues generated from EBCs also helps to buffer agricultural industry risks.

Energy and water usage are inextricably linked; therefore, water savings translate directly into energy savings from conveying less water to a farmer's field. Reduction of N used in the agriculture industry lessens the energy requirement producing the fertilizer and lowers N_2O emissions and nitrate runoff from a farmer's field.

4. EPRI-MSU N_2O OFFSET PROTOCOL

The EPRI-MSU N_2O Offset Protocol provides a methodology for calculating credit for N fertilizer rate reduction. The protocol provides flexibility in achieving N rate reduction. A robust accounting methodology was developed that identifies a baseline N fertilization rate based on farmer's historic data–this is known as the BAU (business as usual) N fertilizer rate. N_2O emissions are calculated for the BAU (baseline) case and for the project reduced N-rate using one of two methods as shown in Figure 2. The difference is the N_2O emissions that would have been emitted during the project, based on the N rate that would have been used absent the project (BAU).

Figure 2 shows the relationship between fertilizer rate and N_2O emissions. Tier 1 is a linear method calculation and Tier 2 is a non-linear calculation equation. Tier 2 is more representative of actual N_2O emissions. As part of the MSU web-based decision support system, a N_2O GHG calculator was developed to allow for quantification of potential N_2O offsets. The calculator makes use of existing USDA and other data; provides comparative CO_2e "costs" of N_2O, soil carbon change, fuel, and fertilizer; and allows for comparison of different scenarios based on crop, tillage, and fertilizer decisions. The calculator is available at www.kbs.msu.edu/ghgcalculator. [12]

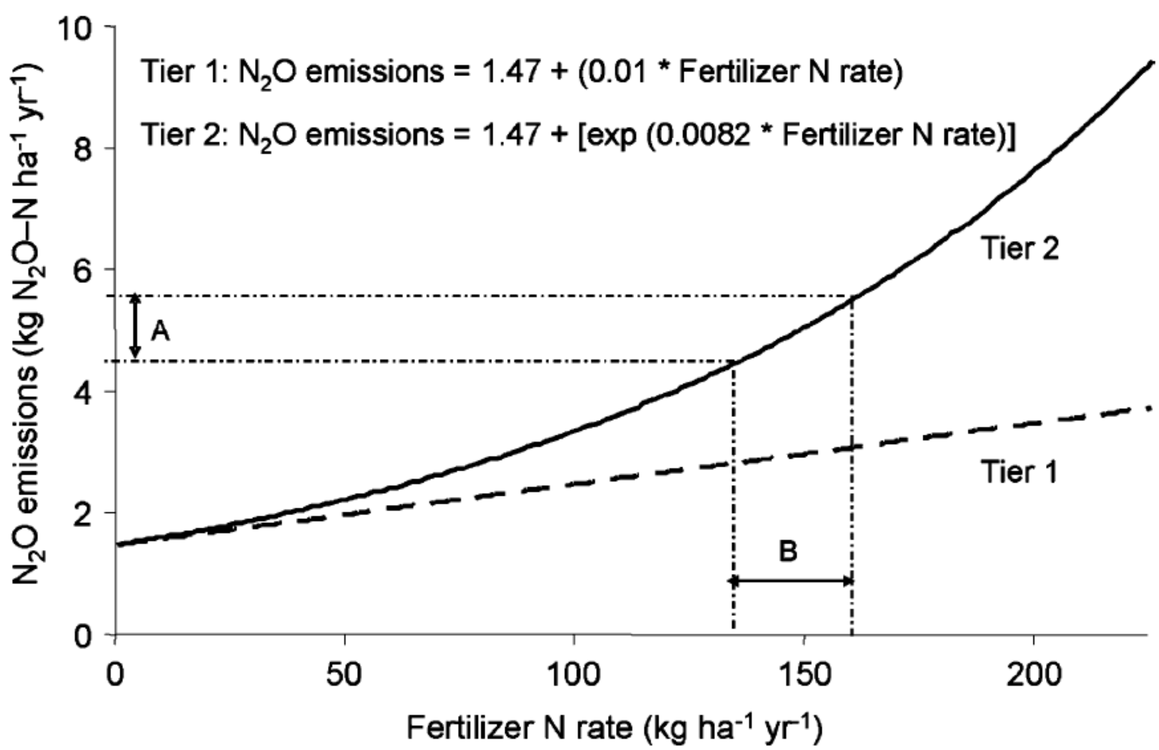

Figure 2. Relationship between N-fertilization rate and N_2O emissions [12]

Two approaches are available:

Approach 1 (preferred method due to finer spatial resolution)–baseline N rate calculated from:

- Site-specific, farmer N fertilizer management records (require at least 5 years prior to project period depending on rotation)

Approach 2 (used if farmer records unavailable or unsuitable)–baseline N rate calculated from:

1. County-level yield records aggregated by the USDA NASS;
2. Yield goal equations for determining N fertilizer rate;
3. Reductions in N fertilizer N rate (N_2O emissions), below BAU threshold result in project additionality. Additionality is assessed using a Performance Benchmark. Under both the American Carbon Registry (ACR) and Verified Carbon Standard (VCS), two tests must be passed:
   3.1. Regulatory Surplus: No mandatory laws or regulations at the local, state, or federal level that requires farmers to reduce N fertilizer rate below BAU rates.
   3.2. Performance Standard: Exceeds a performance threshold that represents BAU rate.

"Common Practice" threshold used that is identical to calculated N rate baseline value, irrespective of whether Approach 1 or 2 is used.

4.1. EPRI-MSU N_2O OFFSETS PROTOCOL LOGIC

The MSU-EPRI N_2O Offsets Protocol is straightforward, transparent, and reasonably flexible without allowing opportunities for gaming the system. It is scientifically robust and applies to most crops and geographic locations. In addition, the methodology has and continues to be validated dating back to 2011 via VCS and ACR. However, despite all these positive attributes, the protocol has been modestly used. Considering how busy farmers are, this is not too surprising. Expanding the use of this protocol requires expanding the project boundaries. Figure 3 is a flowchart of the MSU-EPRI protocol.

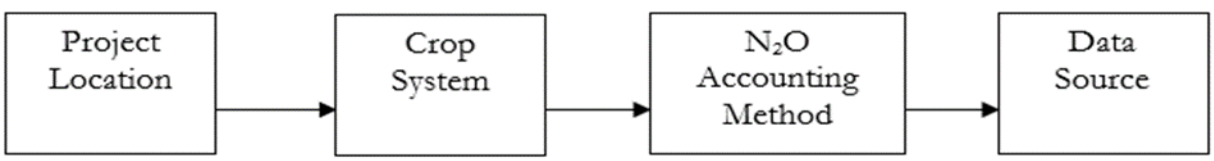

Figure 3. MSU-EPRI Protocol Flowchart

Expanding the boundary from the commodity source to the product end user will greatly expand the potential project beneficiaries. In the environmental industry a hazardous waste material is tracked from "cradle to grave," and similarly in water sampling a 'chain of custody' accompanies all water samples from collection to an end user receiving data results. In a heavily regulated industry this ensures integrity of the process. This same logic should apply to EBCs using a COT to ensure the offsets are legitimate. A COT will link the tangible asset (humate or other raw commodity) to the generated intangible asset (EBCs); thereby, improving the value or ability to monetize the asset.

An effective LCA will link the tangible asset–humate to the intangible asset–offset, enhancing the value of the asset due to increased market confidence in process validity and fraud deterrence. For example, an asset management/tracking system that attaches an identification number (ID) to a unit of humate beginning a COT that geographically identifies where the humate originated (the mine), the characteristics of that humate unit (sample analysis), the movement, any processing and the final use (purpose and location), the linkage to any corresponding offset (carbon, nitrogen, and/or water) and the final disposition or retirement.

4.1.1. TRACKING TAGGANTS

A key element to the COT methodology is the insertion of a taggant that provides a unique digital signature and validates the additionality component for the material. Taggants can be inserted at the optimal point in the product life cycle. Embedded taggant(s) allow a material such as humate to be readily tracked from mining to application. In addition, considering that modern farming now uses technologies such as precision application where materials are applied at a prescriptive rate, the taggant(s) can be measured during application facilitating quantitative record keeping of where and exactly how much of a tagged material was applied in an agricultural plot. This step secures the connection between the tangible (commodity material) and the intangible (EBC).

Nanoparticles can be covertly embedded in a commodity material such as humate in such a way as to provide a unique digital barcode. This technology provides a transformative solution to verify corrective applications of prescriptive doses of materials under variable rate applications. Taggant nanoparticles can be quantified during application and/or verified by field sampling. The unique characteristics (size, shape, density, fluorescence, thermal melting point, etc.) of the nanoparticles allow field sampling to be conducted on site providing field verification of application rates and location of materials immediately.

Error! Reference source not found.4 is a flowchart showing the LCA for a mined product such as humate that can be linked to a GHG offset. The critical component for the LCA is the digital signature which follows the tangible asset (ex. raw commodity) through processing, transportation, packaging, application and finally to the linkage with the intangible associated asset (GHG offset). The digital securitization of GHG offsets associated with changes in agricultural practice will greatly expand the project beneficiaries beyond the MSU-EPRI protocol in two ways:

- by minimizing the potential for fraud; and
- by providing a transparent and trackable method to provide monetary value to all project participants.

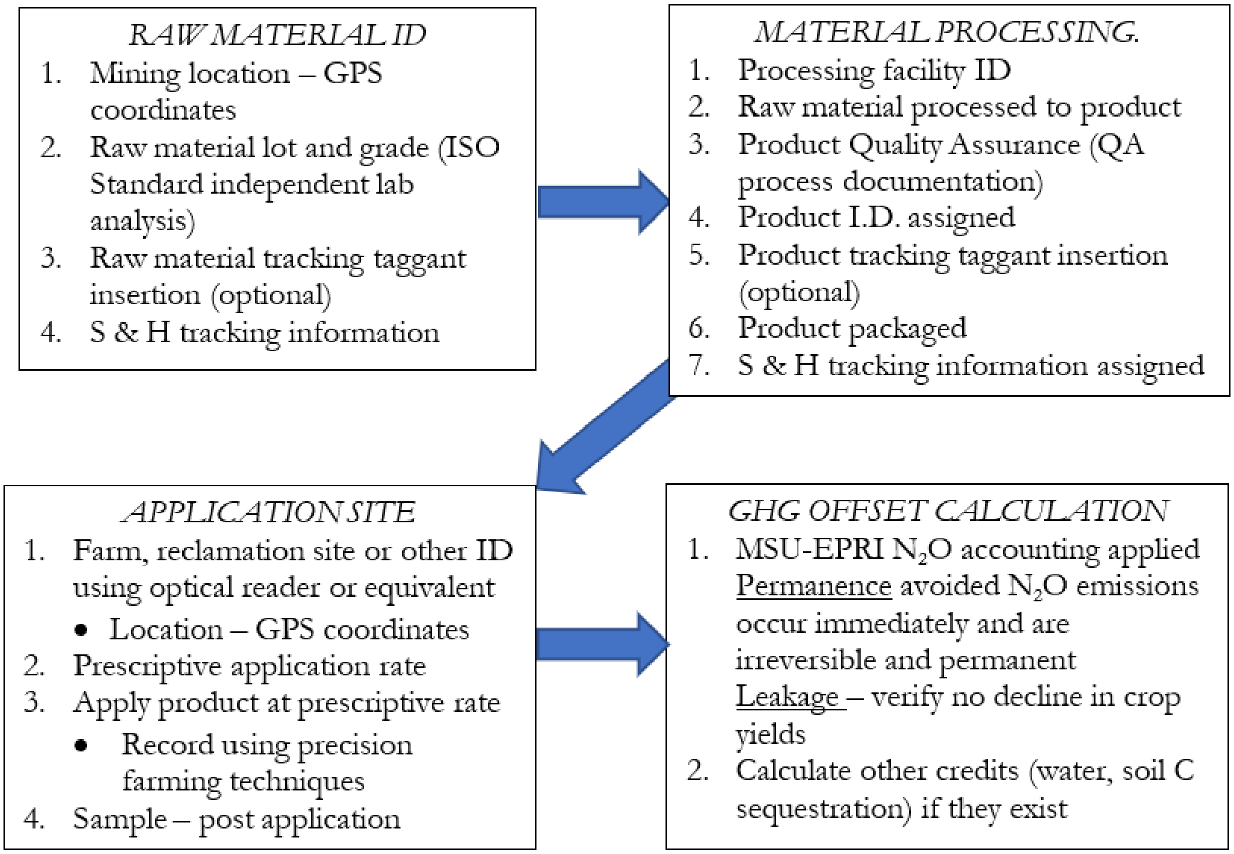

Figure 4. Life Cycle Approach flowchart allowing for blockchain technology application

5. CONCLUSIONS

Genuine carbon standards have been set up with the intention of providing assurances to buyers that the emissions reductions generated by a particular project are indeed real, quantifiable, and additional.

Credible standards are a requirement in such practices to provide high quality, independently verified assessments of the emission reductions produced by a project. There are registries such as the Gold Standard and Verifiable Carbon Registry that take efforts to ensure that projects meet robust and stringent methodology requirements for sustainable development in the local area. However, none of these registries provide an accurate COT or accurate LCA to the offsets opening the door to fraud in the voluntary markets. COT technologies and blockchains can close that door and provide additional environmental benefits simultaneously.

The Compliance Markets are more robust but the method of tagging the project intentions with the project verifiable results are lacking. Further, the expense associated with creation of a carbon equivalent offset is not well understood at this time. The price discover element has been addressed by the current project. Humic products are an inexpensive alternative to the extent their additionality can be verified.

Humate-based products have been used for many years and the science regarding quality of products has advanced over the years culminating in recent ISO standards. These standards are currently under review by Humate Products Trade Association and others including the USDA. Field test trials have proven the concept of additionality on a variety of crops worldwide in accordance with the EPRI-MSU protocols. Add to that newly developed nanomaterials having unique characteristics for material tracking—the validation of agricultural field application quantities is now assured.

To verify the purchase of high-quality carbon offsets and EBCs, it is imperative that companies pursue offsets that have been subjected to rigorous third-party monitoring, reporting, and verification procedures. It is also useful to source EBCs from a reputable offset supplier who can offer transparency in terms of the projects, pricing, and retirement of the carbon credits. The LCA/COT process developed by Lone Tree Technologies provides a transparent, logical method for real time tracking of usage of an agricultural product such as humate. It also provides digital record keeping for nitrogen, water and/or other agricultural inputs (reductions) justifying the concept of "additionality." This COT process enhances the validity and value of the link between the tangible (humate or other) asset and the intangible offset (carbon, water, etc.) asset.

This process could also apply to food security and safety issues as well as a means of COT parties monetizing the value of the benefits derived along the chain.

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