

**Harmon  
Systems  
International, LLC**

*We provide solutions that benefit the world*

National Organic Standards Board  
C/O Robert Pooler, Agricultural Marketing Specialist  
USDA/AMS/TM/NOP  
Room 2510-So., Ag Stop 0268  
P.O. Box 96456  
Washington, D.C. 20090-6456

July 30, 2008

**Re: Resubmit of Harmon Systems International petition for sulfurous acid for inclusion on the National List**

Mr. Pooler:

I know it has been a few years, but, at long last, I am finally resubmitting my petition for sulfurous acid inclusion on the National List once again. Hopefully, I have gotten everything in order and included all of the information you will need this time around. If you do have any further questions or need more information please let me know and I will try to obtain it for you ASAP.

In addition, if you would like, I can obtain testimonial statements on the benefits of using sulfurous acid by various growers and can make myself personally available to the NOSB for any public hearing if you like. Just let me know. My direct email is: [westernso2@aol.com](mailto:westernso2@aol.com) and my home office ph/fax is: 925-376-5340 or you can contact me using the contact information listed below.

Sincerely,

Terry R. Gong  
Manager  
Harmon Systems International, LLC

RECEIVED  
USDA NATIONAL  
ORGANIC PROGRAM  
2008 JUL 32 P 12:05

**2201 Coy Avenue Bakersfield, California 93307**  
**Phone: (661) 396-3570 Fax: (661) 396-3574**  
**email: [h2so3generators@aol.com](mailto:h2so3generators@aol.com) [www.harmonso2generators.com](http://www.harmonso2generators.com)**

**Petition for:**

Sub part G administrative

Synthetic substances allowed for the use in Organic crop production. Section 205.601 (j 2)

**1. Name of Substance:**

Sulfurous Acid ( $\text{H}_2\text{SO}_3$ )

**2. Submitted by:**

Terry R. Gong

Harmon Systems International, LLC

2201 Coy Avenue

Bakersfield, CA 93307

Phone: (661) 396-3570

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**3. When used for Organic crop production:**

The primary use of this material is as an acidifying agent to neutralize and reduce the excessive alkalinity (bicarbonates and carbonates) in the soil/water solution to achieve and maintain an ideal agronomic environment for the crop being grown. However, because sulfurous acid is a weak acid (a compound that disassociates its ions in stages), this material has other significant and useful properties as well. They are: 1.) Even in its most concentrated form, sulfurous acid is a material that is physically safe to handle; 2.) When used properly, sulfurous acid is environmentally safe, and will not leave a toxic residue because the residue itself (when it is transformed into sulfate) actually becomes a nutrient for plants and microorganisms to uptake; 3.) As a weak acid, when sulfurous acid is diluted in water, as it releases its initial hydrogen ion, it acidifies and lowers the pH and transforms it into a solution containing bisulfite. This compound is known to have biocidal properties which enables it to also be used as a means to keep irrigation conveyance systems clean, and to suppress bacteria and pathogenic microorganisms; 4.) Based on weight, cost, and availability, this material is unsurpassed in the total amount of acidity it can deliver into a soil/water system within a specified volume of water and pH; 5.) Because using sulfurous acid provides a myriad of solutions for both conventional and organic growers, it is truly a superior and more natural alternative to anything now in use.

**4. Application rates for Organic crop production:**

One of the most reliable indicators of the agronomic health of an agricultural ecosystem is pH. For most crops, a pH of 6.5 to 7.0 is considered ideal because it is the range in which the most balanced array of nutrients becomes chemically available for plants to uptake, and is a level that favors vital and essential soil microbial activity. Generally, the use of sulfurous acid would be for agricultural ecosystems with soil/water solutions higher than the range stated, however, there will be instances where growers may want to attain a lower pH. In acidic soil regions, the use of this material would be unnecessary or used sparingly. In situations where acidification is needed, the application rates for this material will be determined by the natural buffering capability (resistance to pH change from acid) of the agricultural ecosystem being amended. Some agricultural ecosystems require a significant amount of acidification to induce a pH change, while others may not. Because every location is different, there are no set application rates. Furthermore, because sulfurous acid is unlike other acidifiers, conventional application rates do not apply. And the only way for growers to determine if their agricultural ecosystem needs acidification is to measure the pH of the irrigation water they use, and to test the pH of their soil on a routine basis (at least once a year) and to use it as a guide. This will enable them to regulate the input of this material to attain and stay within the targeted range. Over applying this material is considered remote because: lowering the pH/natural buffering of an agricultural ecosystem beyond the ideal range often takes years and can be easily anticipated and controlled; economically, there is no incentive for growers to over apply this material as too low of a pH will result in producing unfavorable conditions and lower yields; and corrective action (by reducing or terminating the input amount of sulfurous acid or adding lime) to raise the pH can be adjusted easily.

## 5. Source of substance:

Sulfur is a base element and is an essential nutrient for members of the plant and animal kingdoms, and in order for its consumption to occur; it must be transformed from its inorganic form (S) to a state that allows for its uptake to occur ( $\text{SO}_4^-$ ). This process requires energy, either from microbial decomposition (*Thiobacillus*) and/or heat, to oxidize the sulfur into sulfur dioxide ( $\text{SO}_2$ ) and upon doing so, sulfurous acid and other sulfur-containing compounds can be formed. Common examples of sulfurous acid being produced in nature can be illustrated by examining: on going subsurface hydrothermal vents underneath the ocean; surface vents, volcanic eruptions and fumaroles emitting sulfur dioxide and its reaction with seawater, and/or when it spews into the atmosphere where it has an integral part in the natural formation of rain (Figures 1, 2, 3, 4). Other well known (and infamous) producers of sulfurous acid are coal burning power plants. This is because their emissions of sulfur dioxide have been directly linked to cause an abnormal concentration of sulfurous acid to occur within rain water, and as a result, the phenomenon known as “acid rain” (Figure 5).

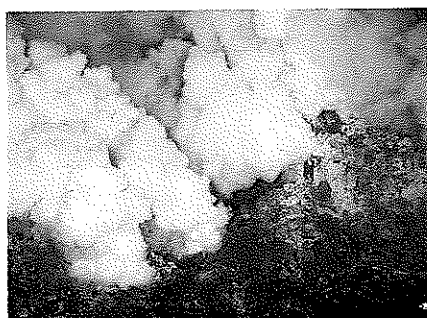


Figure 1. Hydrothermal vent Nikko caldera, Mariana Arc, South Pacific, NOAA Submarine Ring of Fire

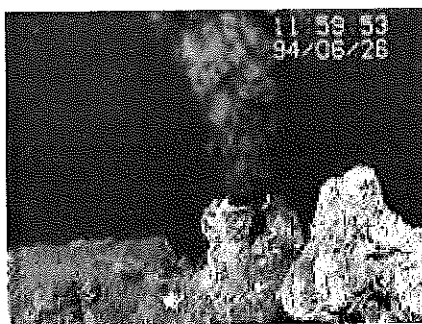


Figure 2. Black Smoker Vent, Juan de Fuca Ridge, North American Plate, located off CA OR WA coast



Figure 3. Surface emission of  $\text{SO}_2$  gas from fumaroles Kilauea Volcano.



Figure 4. Fumaroles vents located at Yellowstone National Park



Figure 5. Coal Burning Power plant

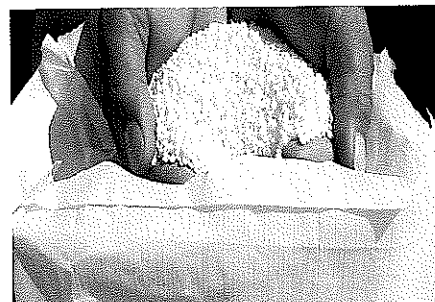


Figure 6. 99.9% OMRI Approved Pure Elemental Prilled Sulfur

Another way sulfurous acid ( $\text{H}_2\text{SO}_3$ ) can be produced is to oxidize elemental sulfur (Figure 6) with a Harmon  $\text{SO}_2$ /Sulfurous Acid Generator (Figure 9 & 10), a technique that controls the burning of sulfur by using a pressurized side stream of water, to effectively scrub and capture the  $\text{SO}_2$  gas created into a concentrated aqueous solution. This process uses 99.9% pure elemental sulfur. It should also be noted that while 99% percent of the elemental sulfur available on the worldwide market today is currently being supplied from the refinement of crude oil (Figure 7), should this material become scarce in the future (as a result of oil fields becoming depleted; geo-political tensions; and/or from the development of alternative energy sources, etc.), in order to continue supplying the sulfur that will be needed, free market dynamics and economics will more than likely cause gradual transition for this material to be obtained by directly mining for it (using the simple method known as the Frasch Process). Regardless of how or where sulfur is obtained, when it has been transformed from its pure elemental state, its beneficial and important life giving properties can be realized (Figure 8).



Figure 7. Crude Oil Refining.

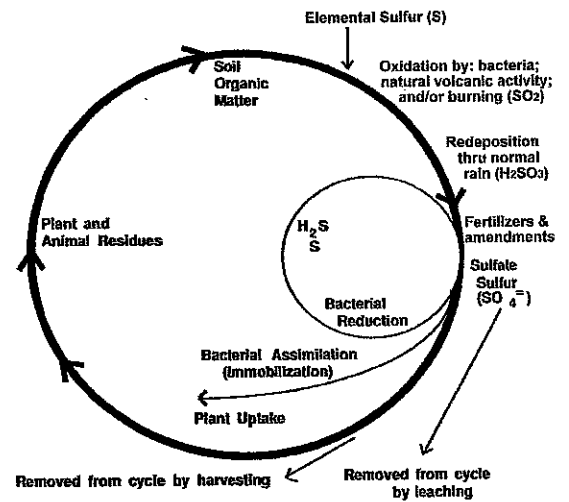


Figure 8. The Sulfur Cycle

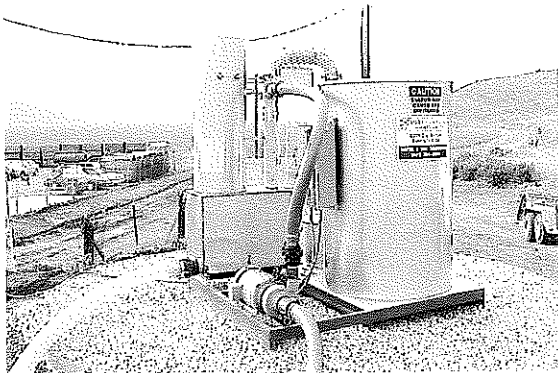


Figure 9. Harmon SO<sub>2</sub>/Sulfurous Acid Generator

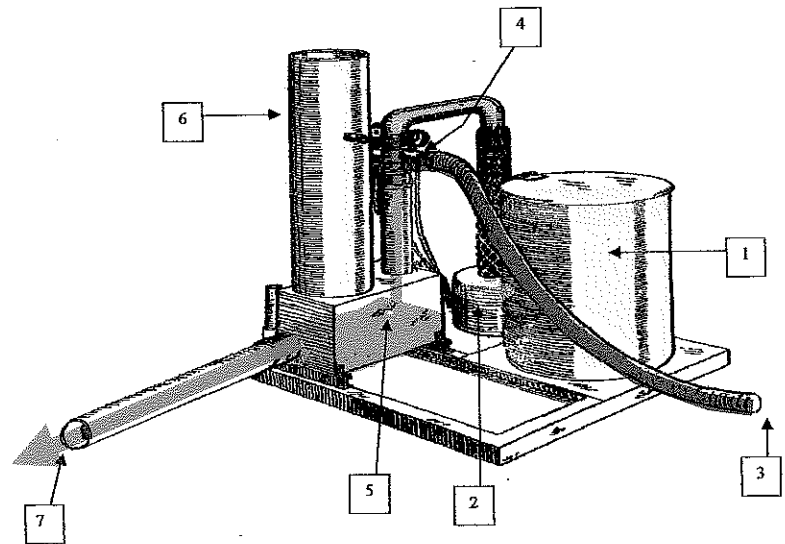


Figure 10. Operational Diagram

(Figure 10) Elemental Sulfur stored in the Hopper (1) supplies material thru a channel to Burner Chamber (2) for oxidation. By regulating a pressurized side stream of irrigation water through a device called the Aspirator, air can be drafted and the burn rate of the sulfur can be controlled (after it has been ignited by a match, propane trigger torch, or electric heating element, no other fuel or heat source will be necessary). The resulting sulfur dioxide (SO<sub>2</sub>) produced is immediately captured to form an aqueous solution of sulfurous acid within the Acid Tank (5). The Scrub Tower (6) scrubs and washes fugitive SO<sub>2</sub> into solution and prevents it from escaping into the atmosphere. Nitrogen (N), which is 79% of air, is drafted through the equipment and ventilated through the tower. The concentrated Sulfurous Acid solution is then discharged via pipe (7) into a canal, reservoir, or injected into an irrigation system main line. Since the fuel source is the sulfur itself, as long as it remains ignited, the production of sulfurous acid will be continuous until such time the material has either been depleted or the flame is extinguished for shut down (turning off the pressurized flow of water and capping off the air/oxygen supply).

6. Summary of previous reviews: See file

7. Information regarding EPA, FDA, and State regulatory registrations:

Sulfurous acid (40 CFR 180.910)

<http://www.epa.gov/fedrgstr/EPA-PEST/2005/June/Day-01/p10680.htm>

<http://www.cpda.com/TeamPublish/uploads/InertRevocation.July12.2005.doc>

## 8. Chemical Abstract Service number:

#7782-99-2 - sulfurous acid was not listed with the US EPA Envirofacts Warehouse and visitors were referred to: [http://www.scorecard.org/chemical-profiles/summary.tcl?edf\\_substance\\_id=7782-99-2](http://www.scorecard.org/chemical-profiles/summary.tcl?edf_substance_id=7782-99-2), a non-governmental website that had some information on the material. That information is as follows: Human Health Hazards - as a suspected gastrointestinal or liver toxicant; Hazard Rankings – data lacking, not ranked; Chemical Use Profile – no data on industrial or consumer use; Rank Chemicals by Reported Environmental Releases in the U.S. – no data on environmental releases; Regulatory Coverage – not on chemical lists; Basic Testing to Identify Chemical Hazards – 6 of 8 basic tests to identify chemical hazards have not been conducted on this chemical, or are not publicly available according to US EPA 1998 hazard data available study; Information Needed for Safety Assessment – Lacks at least some of the data required for safety assessment. See risk assessment data for this chemical from US EPA or Scorecard; Links – New Jersey Fact Sheet.

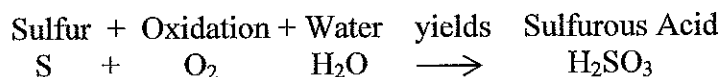
The information in the NJFS report is rather limited as there were no details as to the concentration level the sulfurous acid was when they evaluated it. It is important that we recognize this for several reasons: 1.) Table wine is actually sulfurous acid because it is usually is dosed with SO<sub>2</sub>, it becomes a solution containing Bisulfite (HSO<sub>3</sub><sup>-</sup>), and has a pH range of about 3.3 to 3.7; and when consumed in moderation, considered to have health benefits and not considered harmful to humans. 2.) Since the proposed use of sulfurous acid is not for direct human consumption, but, specifically to amend soil/water systems to a pH of 6.8 (or lower to 5.5 if the crop being grown requires it), the manner in which this material will be used will be diluted and 1,000 to 10,000 times less acidic. Clearly, sulfurous acid should not pose a health risk and should improve occupational worker safety (by removing their exposure to dangerous acids).

## 9. The substance's physical properties and chemical mode of action:

Sulfurous acid and sulfuric acid are different materials. A comparison of how these two acids are formed will make this evident and easier to understand its physical properties and chemical mode of action.

### Sulfurous Acid Production

Sulfurous Acid is produced whenever sulfur dioxide gas makes contacts with water. This process is as follows:



### Sulfuric Acid Production

Most of the sulfuric acid manufactured is produced using the Contact Process, a process involving the catalytic oxidation of sulfur dioxide (SO<sub>2</sub>), to sulfur trioxide, (SO<sub>3</sub>) and illustrated by the following:

1. Solid sulfur (S), is burned in air to form sulfur dioxide gas(SO<sub>2</sub>)  
 $\text{S(s)} + \text{O}_2(\text{g}) \longrightarrow \text{SO}_2(\text{g})$
2. The gases are mixed with more air then cleaned by electrostatic precipitation to remove any particulate matter.
3. The mixture of sulfur dioxide and air is heated to 450°C and subjected to a pressure of 101.3 - 202.6 kPa (1 -2 atmospheres) in the presence of a vanadium catalyst to produce sulfur trioxide, SO<sub>3</sub>(g), with a yield of 98%.  
 $2\text{SO}_2(\text{g}) + \text{O}_2(\text{g}) \longrightarrow 2\text{SO}_3(\text{g}).$
4. Any unreacted gases from the above reaction are recycled back into the above reaction.
5. Sulfur trioxide, SO<sub>3</sub>(g) is dissolved in 98% (18M) sulfuric acid, H<sub>2</sub>SO<sub>4</sub>, to produce disulfuric acid or pyrosulfuric acid, also known as fuming sulfuric acid or oleum, H<sub>2</sub>S<sub>2</sub>O<sub>7</sub>.  
 $\text{SO}_3(\text{g}) + \text{H}_2\text{SO}_4 \longrightarrow \text{H}_2\text{S}_2\text{O}_7$   
This is done because when water is added directly to sulfur trioxide to produce sulfuric acid  
 $\text{SO}_3(\text{g}) + \text{H}_2\text{O}(\text{l}) \longrightarrow \text{H}_2\text{SO}_4(\text{l})$   
the reaction is slow and tends to form a mist in which the particles refuse to coalesce.
6. Water is added to the disulfuric acid, H<sub>2</sub>S<sub>2</sub>O<sub>7</sub>, to produce sulfuric acid, H<sub>2</sub>SO<sub>4</sub>  
 $\text{H}_2\text{S}_2\text{O}_7(\text{l}) + \text{H}_2\text{O}(\text{l}) \longrightarrow 2\text{H}_2\text{SO}_4(\text{l})$

(above information sourced from <http://austute.com.au/sulfacid.html>)

Although both acids appear to be similar, the comparative difference in their chemical mode of action is that when sulfuric acid is introduced to water, as a strong acid (reacts with a complete dissociation of ions) the two acidifying hydrogen ions ( $2\text{H}^+$ ) are immediately released to react with bicarbonates and carbonates ( $\text{HCO}_3^-$  and  $\text{CO}_3^{2-}$ ) that may be present to yield water ( $\text{H}_2\text{O}$ ) and carbon dioxide ( $\text{CO}_2$ ) (Figure 11).

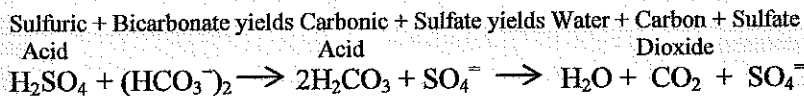


Figure 11. Acidification with Sulfuric Acid to 6.5 pH reduces only 42% of the bicarbonates in water.

As the carbon dioxide gasses from the water, the Total Alkalinity and buffering capability of the water is reduced, and the remaining sulfate ( $\text{SO}_4^{2-}$ ) is then left in a solution that is normally adjusted to a pH of 6.5 (in order to protect the components of the irrigation conveyance system). However, while the reduction of carbonates and bicarbonates has the appearance of improving the irrigation water somewhat, a more detailed examination reveals that sufficient neutralization has not yet occurred. This is because at this pH level, the actual reduction of Total Alkalinity is less than 42%, which allows more than 58% to remain intact within the system (Figure 12).

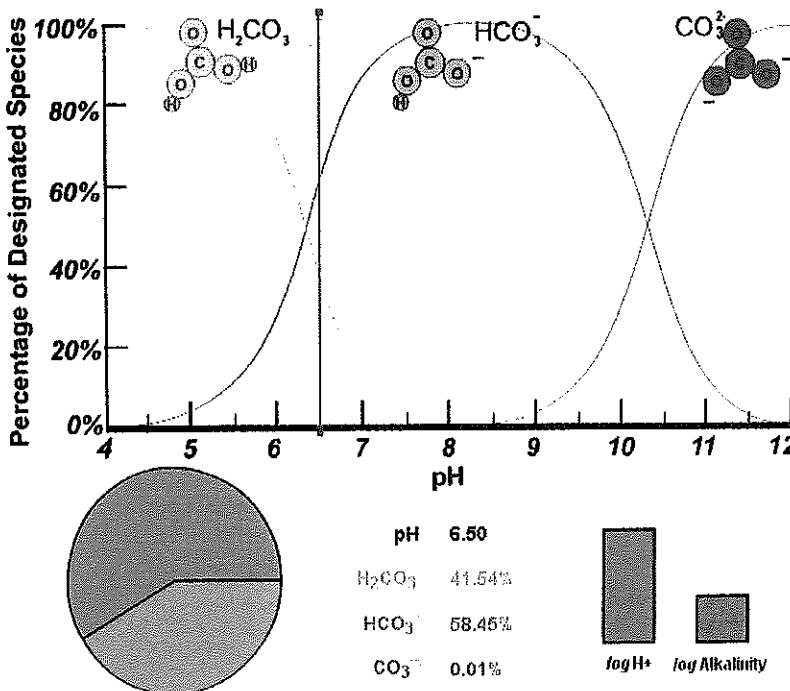
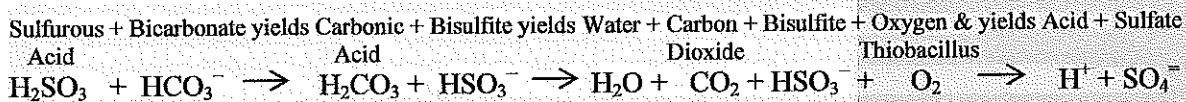


Figure 12. Alkalinity/Buffering Curve. Note the amount of bicarbonate ( $\text{HCO}_3^-$ ) that still remains even after the water has been adjusted to 6.5 pH.

Sulfurous acid has a different reaction sequence. As a weak acid (reacts with a partial dissociation of ions), it releases a single hydrogen ion ( $\text{H}^+$ ) while allowing the other to remain bonded and held in solution as Bisulfite ( $\text{HSO}_3^-$ ). And so, while this solution can also be adjusted to a pH of 6.5, in reality, the overall acidity of this solution is greater, because after it has been applied to the soil, within hours *Thiobacillus* bacteria will oxidize and complete the reaction by converting the Bisulfite into Sulfate ( $\text{SO}_4^{2-}$ ) and upon doing so, releases the remaining hydrogen ion ( $\text{H}^+$ ) into the soil (Figure 13). It is this delayed release of acid, and the logarithmic nature of pH (a tenfold difference between each point), that enables elimination of the remaining 58% of alkalinity within the water to occur, but also, the means to deliver the necessary acidity (into the soil) that is required to improve an agricultural ecosystem.



Acidification with Sulfurous Acid to 6.5 pH initially releases half of its available acidity (to reduce bicarbonates by 42%), then delivers the remaining half...

into the soil. Depending on how the water is actually buffered, it is through this delayed release of acid that the remaining bicarbonates (58%) are eliminated and how soil carbonates are dissolved.

Figure 13. Acidification Sequence with Sulfurous Acid

Because sulfurous acid will have a residual amount of acidity leftover (after completely neutralizing 100% of the Total Alkalinity emanating from the water source), this surplus of acid is now available to interact with soil carbonates. The importance of this cannot be overstated because carbonates (CO<sub>3</sub>) require twice as much acid to neutralize compared to bicarbonates found in water (Figure 14).

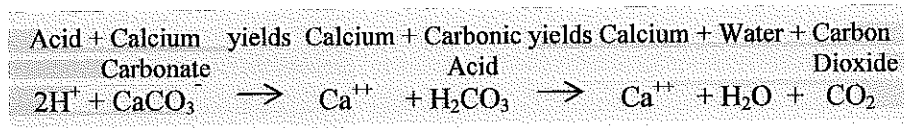


Figure 14. Neutralization of Lime Calcium Carbonate

While acidification will not reduce or eliminate the existing salinity in water and will elevate the water's overall TDS, by preventing the formation of lime and providing more acid, more pore space throughout the soil profile can be created (Figure 15). And, it is this extra acidity that enables: the overall pH of the agricultural ecosystem to lower; mineral nutrients to become soluble and available for plants to uptake; salts to leach; and the creation of healthier and improved soil environment to occur (by reopening and keeping the soil/air interface open to allow oxygen and carbon dioxide can exchange deeper throughout the soil profile) so that important and vital microbial activity can take place.

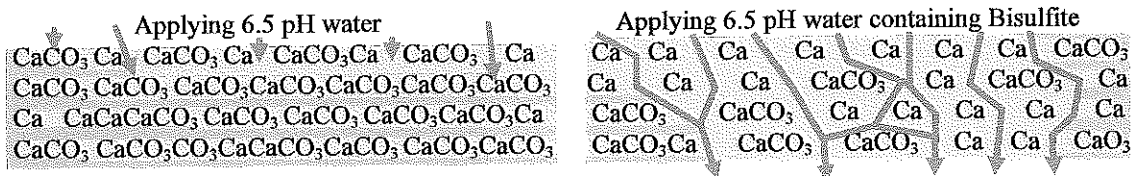


Figure 15. The extra acidity provided by Bisulfite dissolves more lime and creates more pore space for water leach away salts and oxygen to penetrate deeper.

As salts (Ca<sup>++</sup>; Mg<sup>++</sup>; Na<sup>+</sup>; K<sup>+</sup>, etc.) detach from soil exchange sites, due to the two negative charges and the high solubility of sulfates (SO<sub>4</sub><sup>-</sup>), these materials eventually become bonded within the soil water solution, and as the solution continues its downward migration, both are carried and leached deeper through the soil profile. Eventually, the ability of this material to provide a combination of additional acidity and sulfates into an agricultural ecosystem may prove itself to be our most important management tool for preventing soil salinity.

**b. Toxicity and environmental persistence:**

First, the toxicity of sulfurous acid is pH dependent. The lower the pH, the greater the concentration of free sulfur dioxide (SO<sub>2</sub>) and bisulfite (HSO<sub>3</sub><sup>-</sup>) in the soil and water solution. This is how over acidifying with sulfurous acid can become toxic to an agricultural ecosystem. Therefore, it will be important for sulfurous acid users to monitor and avoid lowering the pH of the soil and water solution beyond what is ideal (6.5 to 7.0) for the crop being grown. Controlling the pH is simple, and economically, growers will have ample incentive to do so.

Second, when used as prescribed, sulfurous acid should not be toxic to the environment because the biocidal effect of the Bisulfite (HSO<sub>3</sub><sup>-</sup>) is lost within hours, and because the release of additional acidity occurs sequentially, it is less likely to overwhelm the microbes within a system.

Third, the remaining sulfate (SO<sub>4</sub><sup>-</sup>) then becomes a nutrient for microorganisms and plants to uptake.

Fourth, sulfate is not listed or considered as a carcinogen.

Fifth, because sulfur is continuously being transformed, in the sulfate (SO<sub>4</sub><sup>-</sup>) form, it will remain in as a nutrient, as long as the soil/water system is aerobic. However, if the system were to become anaerobic (water-logged conditions by not providing enough acidity to dissolve and create more pore space, poor drainage or having a perched water table, etc.), anaerobic bacteria would then convert sulfate into hydrogen sulfide (H<sub>2</sub>S). In this state, it transforms from being a nutrient and it can become toxic.



**c. Environmental impacts from its use or manufacture:**

The environmental impacts for using sulfurous acid will be significant and positive. This is because while water is the foundation for life, it can also be the source from which most agronomic problems stem. To understand why, it is important that we begin by: 1.) Making a more thorough reexamination of the water we use and how it has affected our agricultural ecosystems. 2.) Then reexamine what rain does.

First, the major constituents of water consist of various electrically charged materials called cations and anions, and their sum total is measured as Total Dissolved Solids or TDS (Figure 16). Some of these materials, calcium (Ca<sup>++</sup>) and bicarbonates (HCO<sub>3</sub><sup>-</sup>), because of their opposite charges, have an attraction to bond with each other to form calcium carbonates or lime, magnesium carbonates, and sodium and potassium bicarbonates as well (Figure 17). To solve the salinity issue, it is important that we recognize that the solution is not necessarily the removal of the salts themselves, but in recognizing TDS's Total Alkalinity component as the main culprit that causes salts to accumulate. This is because 1 meq./L of bicarbonates (61.02 ppm) approximates 200 lbs. of lime-forming potential for every acre foot of water (A & L Labs). For example, water containing 5 meq./L of bicarbonates would apply nearly 1,000 lbs. of lime to the soil for each acre foot applied.

Since the only place for lime to form would be in the soil's existing pore spaces, as this happens, they begin to seal and plug, and a degrading domino effect occurs. It lowers the overall amount of available calcium from dominating soil exchange sites and increases the Sodium Adsorption Ratio (SAR). This leads to slower water infiltration, shallow and uneven penetration, decreases the soil's water holding capacity, induces water-logging, water runoff, greater surface evaporation, and causes salts to begin accumulating at or near the soil/air interface. It also creates an imbalance to the soil's natural bio-diversity by suffocating vital aerobic microbial activity.

Cations:		
Calcium	Ca <sup>++</sup>	
Magnesium	Mg <sup>++</sup>	
Sodium	Na <sup>+</sup>	
Potassium	K <sup>+</sup>	
Anions:		
Bicarbonate	HCO <sub>3</sub> <sup>-</sup>	Total Alkalinity
Carbonate	CO <sub>3</sub> <sup>=</sup>	
Chloride	Cl <sup>-</sup>	
Sulfate	SO <sub>4</sub> <sup>=</sup>	
<b>Total Dissolved Solids</b>		

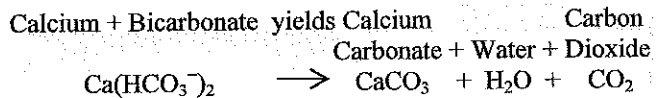


Figure 17. The formation of Lime.

Figure 16. The major constituents in water.

To prevent lime from forming, the most practical way is to add an acidifying agent into the system. Traditionally, in an attempt to accomplish this, we have applied soil sulfur, and/or added sulfuric acid, and other kinds of acidifiers into our irrigation water. And while these techniques may appear to achieve some positive short term results, the success is partial. This is because none of these methods have ever been able to deliver the required amount of acidity needed to keep our agricultural systems sustainable over the long term. They don't even come close. To understand why we simply need to re-examine how nature introduces acidity into an ecosystem – with rain. Contrary to popular belief, normal rainwater is naturally acidic and has a pH that averages between 5.2 to 5.6 (Figure 18). Rain is the universal solvent because the acidity contained within it has been dissolving lime and other soil minerals for eons. If rainwater were neutral or alkaline this could not occur. Rain is the medium in which nature delivers acidity.

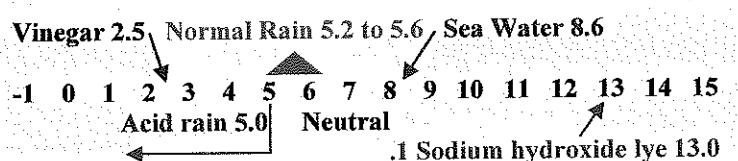


Figure 18. pH Chart



Rain obtains its acidity by absorbing carbon dioxide (CO<sub>2</sub>) and sulfur dioxide (SO<sub>2</sub>) from the atmosphere (US EPA 2004). Not counting those that lie beneath the sea, there are about 590 surface volcanoes known to exist (Figure 19). Currently, there are at least 57 with either ongoing or some activity within the last 12 months. Emission rates of SO<sub>2</sub> from active surface volcanoes often range from <20 tons/day to >10 million tons/day. In 1991, Mount Pinatubo, a volcano in the Philippines, released an estimated 17 to 20 million tons of sulfur dioxide into the stratosphere to an altitude of more than 20 miles (Figure 20). It was determined that Mount St. Helens released about 2 million tons of sulfur dioxide between 1980 and 1988. Mount Spurr in Alaska released about 240,000 metric tons of sulfur dioxide, spread over 370,000 km. A recent sulfur dioxide leak at the BHP Hawaii Petroleum Refinery on O'ahu emitted about 8,900 pounds (3 tons) during a 34-hour period. In contrast, the ongoing activity at Kilauea releases about 2,000 tons of SO<sub>2</sub> per day into the lower troposphere - emitting about 150 to 200 tons of sulfur dioxide from the summit caldera (Halema'uma'u) and an additional 700 to 1,250 tons per day from Pu'u 'O'o when in eruption (Figure 21). Volcanoes are responsible for 43% of the total natural S flux in the atmosphere each year; with the remainder from the burning of fossil fuels and in the form of hydrogen sulfide (H<sub>2</sub>S) from anaerobic conditions such as those found in swamps and waterlogged soils (USGS & UND 2004).

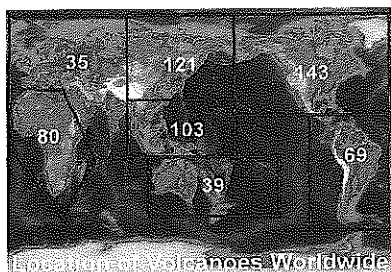


Figure 19. 590 known volcanoes.

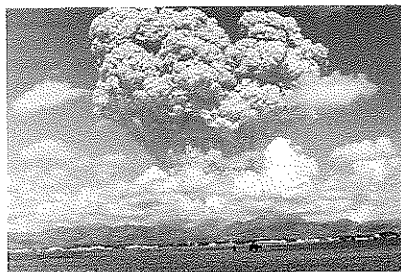


Figure 20. Mt. Pinatubo, Philippines

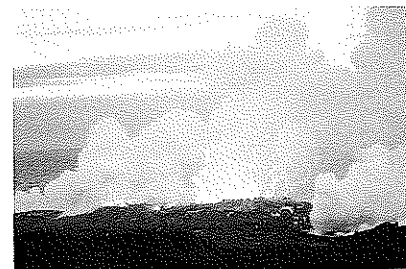


Figure 21. Kilauea, Hawaii

Again, since soils will always acquire the characteristics of the materials applied upon it, rainwater, including the lack of it, remains the most influential factor of all. This is why arid and/or semi arid regions tend to have soils that are alkaline or basic, with soil pHs greater than 7.0, and why high rainfall areas have soils that are acidic, with pHs lower than 7.0 (Figure 22). By recognizing what gives rainwater its unique and intrinsic qualities, we can then mimic and do exactly what nature does.

There are instances where the acidity of rainwater can become harmful, such as when rain falls in regions where extensive fossil fuel burning (coal) occurs (Figure 23). Atmospheric sulfur dioxide acidifies rainwater even further (< 5.0) and it falls uncontrolled onto lakes, rivers, creeks, forests, etc. If this type of rain should fall on high rainfall regions, with the buffering capability of the environment already depleted and soils already in a naturally acidic state, it accelerates the leaching of soil minerals, which often leads to nutrient imbalances and conditions in which metals such as aluminum become soluble and toxic to fish, wildlife, and vegetation (NADP 2003).

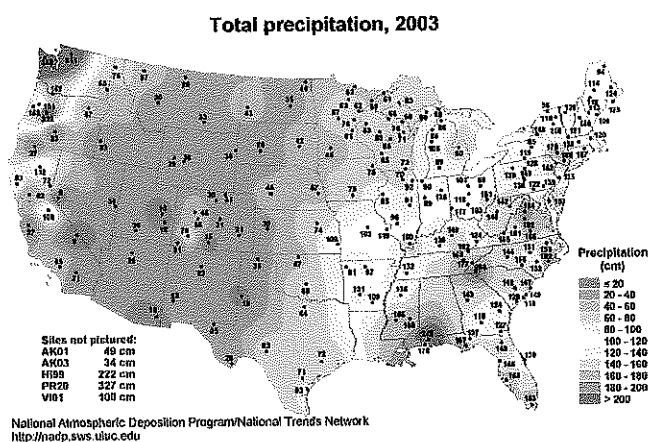


Figure 22. Rainfall concentration.

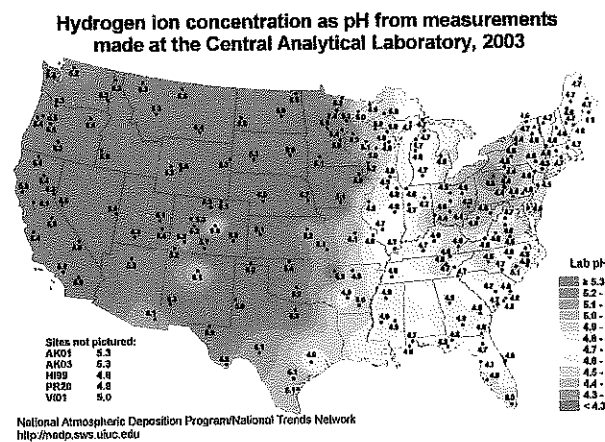


Figure 23. Acid rain concentration.

This explains why in areas where buffering has already been depleted, further acidification of the soil water solution would be inappropriate and detrimental. These areas need to raise the pH (by adding lime) not lower it. However, in areas with alkaline or basic free lime soils, such as arid and semi-arid regions, acidification is not only ideal, but essential, if damage and salt accumulation is to be prevented. And, unlike acid rain, with the use of pumps, water conveyance systems, and modern irrigation equipment, it is possible to control with great precision the pH, volume, rate, and where to apply water after it has been acidified (Figure 24). Thus, the use of a SO<sub>2</sub>/Sulfurous Acid Generator is similar to having a “miniature volcano” to transform alkaline irrigation water in such a way that mimics natural rain.

While it may be common to introduce acidification by applying sulfur-containing amendments directly on soil that will be irrigated (Figure 25), it is less than ideal for the following reasons. First, to induce the acidifying reaction, it requires oxidization of the sulfur by *Thiobacillus* bacteria, a slow process that oftentimes requires many years to attain completion. Second, in an effort to accelerate this reaction, some soil sulfurs may be manufactured using Bentonite clay (10%) to bond fragmented sulfur pieces (90%) together, and upon water contact disintegrates and releases the sulfur particles. This type of sulfur is designed to allow greater surface contact for *Thiobacillus* decomposition. The accumulation of this additional material to the soil over time can be detrimental. Third, bacterial activity varies with soil temperature (Ingham 2000), which causes this method to be unpredictable and unreliable for neutralizing the volume and rate bicarbonate/carbonate contaminants are introduced. Fourth, more water (and salts) will flow and collect in areas that are lowest, which causes this method to be susceptible to under and over application of material. Fifth, as the sulfur particles migrate downward, some of the acidifying reaction takes place below the surface, instead of at the soil/air interface where it is most needed. Sixth, since this method of acidification occurs at the soil, it allows bicarbonates/carbonates the opportunity to make physical contact with the soil and to react with any supplemental calcium amendments that may have been added. This allows even more lime to form. Seventh, due to the tremendous volume needed during initial application, this method is perhaps the harshest means to introduce sulfur into a system as the initial acidifying reaction can become toxic and disruptive to existing microbial populations (Soil Quality Indicators: pH. January 1988).

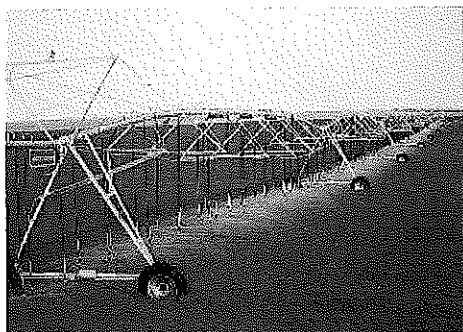


Figure 24. Sprinkler Irrigation

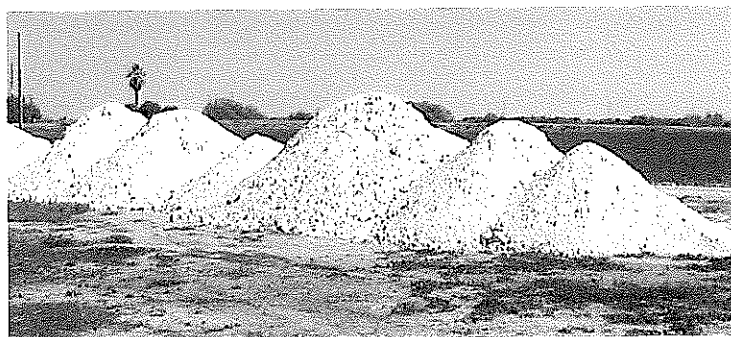


Figure 25. Elemental soil sulfur.

There are many reasons to acidify the water with sulfurous acid. First, it completely eliminates 100% of the Total Alkalinity problem emanating from the water supply. Second, as already noted, water is an efficient and natural means to deliver acidity to soil. Third, unlike acidifying soil amendments that rely on the energy derived from years of microbial oxidation of sulfur to release acidity, this same process can be greatly accelerated by using the heat energy from the sulfur itself for oxidation. Fourth, acidifying with soil amendments has essentially one purpose – they attempt to remove the problem-causing materials after they have already been applied and contaminated the soil. Fifth, proper acidification is also how the problem of sodium can be managed. This is because if the water being applied contained excessive levels of sodium (Na<sup>+</sup>), with sufficient acidification, a supplemental calcium source such as gypsum (Figure 26) can now be added into the system to counter the detrimental effects the sodium would have. Otherwise, the calcium being added would simply react with the bicarbonates/carbonates to form even more insoluble lime inside the soil pores (Ruehr 2004).



Figure 26. Supplemental Calcium – Gypsum ( $\text{CaSO}_4$ )

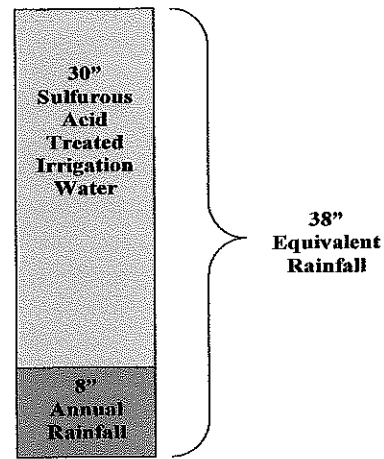


Figure 27. Rainfall Equivalent

The importance of acidification is that it allows the input of supplemental calcium to remain available to out-compete sodium from dominating soil exchange sites. The combination of these two treatments helps to maintain good soil porosity, water infiltration, and enables salts, contained in the water source and those native to the soil, to leach continuously. Thus, soils receiving acidified water would essentially be receiving an extra amount of rainfall over and above its annual total (Figure 27). The benefit of this extra water and acidity should progressively lower the existing soil pH from alkaline to a range 6.5 to 6.8 which favors most agricultural crops (Soil Quality Indicators: pH. January 1988) and cause it to begin assuming the characteristics found in higher rainfall areas.

Rainwater's effect on ecosystems throughout the world provides a reliable source of information as to what would happen if more acidified water were applied onto soil. As additional pore space is created, it allows for greater oxygen and carbon dioxide to exchange. In this environment, a larger number of microorganisms can colonize and grow. As their population continues to flourish and multiply, they remain integrated as a *soil food web* (Ingham 2000) and their combined activity rapidly and efficiently sequesters more organic matter back into the soil, making it healthier and more fertile (Figure 28). Note that it is the acidity within rainwater (not the volume of water) that created these ecosystems (imagine how much longer it would have taken if rainwater were neutral).

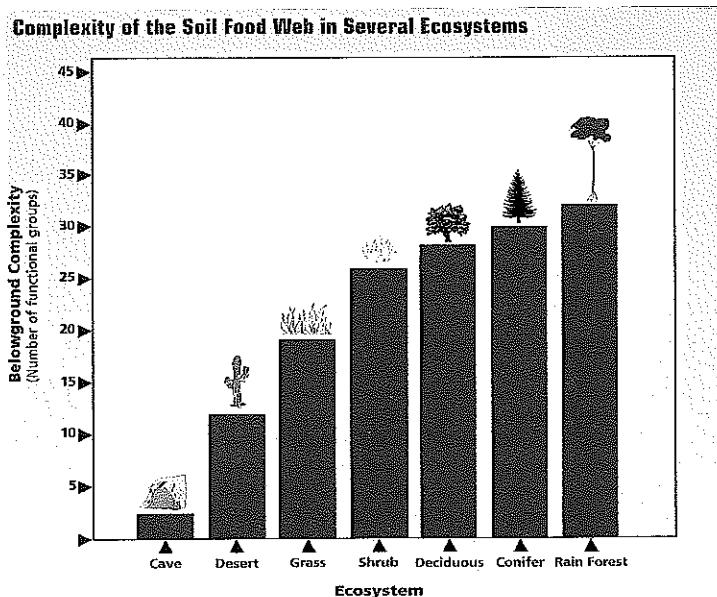


Figure 28. Complexity of Ecosystems

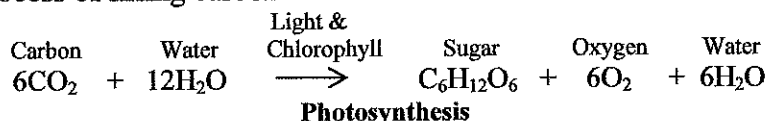


Figure 29. Agricultural tail water runoff

Additional pore space allows a faster and deeper penetration of water, and as a result, less water is wasted or needed, the soil's water holding capacity is increased, and the potential for runoff of silt and non-point source pollution is minimized or curtailed (Figure 29). This allows growers to use less water and to lessen

the demand on limited ground and surface waters, leaving more for the environment and wildlife. Furthermore, by increasing the porosity throughout the soil, fewer inputs will be needed because a healthy and thriving bio-diverse microbial population will serve to feed and protect plants naturally. The use of sulfurous acid (due to the additional acidity and properties Bisulfite has) will not only be a boon for organic growers, it also represents the most important major step that will enable more conventional growers to wean themselves from using synthetic fertilizers and soil fumigants (such as methyl bromide).

While this may not be the primary purpose, as a by product, another environmental benefit for amending water with sulfurous acid is the ability to naturally suppress aquatic plant growth in water conveyance systems (Figure 30) without the use of toxic pesticides. This can be easily explained by understanding how plants grow. The primary factors that influence plant and root growth include light, temperature, oxygen, salt concentration, pH, and the availability of nutrients, etc. Carbon is the building block for plant life and Photosynthesis is the process of fixing carbon from carbon dioxide. That chemical reaction is as follows:



Since sulfurous acid neutralizes bicarbonates into water and carbon dioxide, as it vents from the water, the carbon source is also depleted from the irrigation water as well. By lowering the pH to the ideal range, not only can water quality be improved, the photosynthesis of aquatic plants can also be controlled. This is how this material can also be used to suppress and regulate the rate of growth of aquatic plants in conveyance systems without the use of toxic pesticides, and in a way that is environmentally safe.



Figure 30. Algae in irrigation canals and reservoirs



Figure 31. Improving marginal soil to sequester more atmospheric CO<sub>2</sub> into organic soil carbon. Area on left received irrigation water treated with sulfurous acid while the area on the right received none. The annual rainfall for this area is 8 inches.

While the neutralization of bicarbonates/carbonates will release carbon dioxide into the atmosphere, and this may appear as a negative initially, upon closer examination, it is actually the first step towards the reduction of greenhouse gases. This is because in order to sequester more carbon into the organic form, we must recognize that we must liberate it from its inorganic form first. In other words, by removing CO<sub>2</sub> from our water source (by adding acid to neutralize CO<sub>3</sub> and HCO<sub>3</sub>) we can lower its pH, improve the quality of it, and use it as the medium to deliver the acidity that is needed to dissolve soil carbonates CO<sub>3</sub> (both native to the soil and those formed as a result of applying alkaline irrigation water). Doing so will adjust the pH of the soil/water solution to where it is the most ideal (a pH of 6.8 for most crops) because plant nutrients become readily available and proportionately balanced; and for soil microbial activity to be at its highest. All of this contributes to improved soil fertility and optimal agronomic conditions. It is through this process that marginal and badly degraded farmland can be transformed to sequester even more carbon (into the organic form) than ever before, and how a beneficial net gain in carbon sequestration will occur. Worldwide, about ¾ of the earth's soil organic carbon (SOC) lies within one meter of the surface. In the United States, it has been estimated that as much as 50% of our arable soils have lost their original

amount. With the use of sulfurous acid and proper management, not only can the original SOC be returned, it is now possible to store an even higher amount as well. This is why solutions to reducing atmospheric CO<sub>2</sub> and improving the productivity of soil are intrinsically linked (Figure 31).

When used properly, the positive overall effects sulfurous acid will have on the environment will be astounding. It will: reduce water waste and promote water savings; prevent salt accumulation and restore health to our farm ground; help achieve greater sequestering of carbon back into the soil in the organic form than ever before; result in weaning more farmers away from the use of synthetic inputs and GMOs; and provide the basic foundation for IPM; etc.

Environmental testing conducted on the Harmon SO<sub>2</sub>/Sulfurous Acid Generator has found that this process of making sulfurous acid is environmentally safe (see information previously submitted).

**d. Effects on human health:**

Sulfurous acid, even in its most concentrated form, is a weak acid and has a pH of about 2.0 (which is relatively the same pH of lemonade). Asthmatic people may be allergic and can have an adverse reaction to sulfites. Again, although this will not be its intended purpose, it is widely known that Bisulfite can be consumed in high concentrations without having any major side effects (such as wine with a pH of 3.8).

**e. Effects on soil organisms, crops, or livestock:**

As previously mentioned, sulfurous acid diluted in water can have limited biocidal properties. Although Bisulfite (HSO<sub>3</sub><sup>-</sup>) is known to suppress microorganisms, having the ability to deliver the additional acidity needed to keep or reopen the soil/air interface increases the exchange of oxygen and carbon dioxide, and creates more pore space for water to penetrate deeper to leach away salts. This in turn results in a more optimal environment for microbial populations to re-colonize and grow beyond what may be lost. Overall the trade-off and net result should be far more beneficial than detrimental. In addition, when Bisulfite is transformed into sulfate, it becomes a nutrient for plants to uptake and can be immobilized by microorganisms.

**10. Safety Information and MSDS:**

The elemental sulfur material (in prilled pastille form) used in this process will be 99.9% pure OMRI approved and listed. The safe use and handling of this material and sulfurous acid can be obtained by visiting the MSDS Solutions website at MSDS.com.

**11. Research Information about the substance:**

Due to the apparent confusion by many within the agricultural scientific community as to the actual reaction sequence of sulfur dioxide when it is combined with water, accurate scientific research information is not known to exist, and may not be available from this sector. However, the use and effects of sulfur dioxide in Enology and winemaking, the drying and preservation of fruit, and as an alternative way to disinfect municipal sewage and wastewater, etc., are known to exist. Also, since it is logical that this process is essentially mimicking natural rain, by examining soils and ecosystems throughout the world, ample information and the most reliable scientific model as to what sulfurous acid has and continues to do is “right in front of us”. In fact, the best information available is being revealed to us by nature everyday.

**12. Petition Justification Statement:**

First, while the broadcast application of OMRI approved elemental sulfur on soil, given enough time, can ultimately produce some amount of acidity, the effectiveness of this method is limited (as noted in Section 9 c) and it cannot deliver the necessary acidity in a uniform manner and at a rate needed to keep the pH of a system in balance.



Second, the only available non-synthetic acidifying materials are alginic, citric, and lactic. These materials are ineffective, impractical, costly, and limited in their availability. The use of sulfurous acid is more natural, effective, and a more practical means to provide acidity.

Third, perhaps the most compelling reason can be found by examining the history of the flood plain of the Tigris and Euphrates Rivers, known as the “Fertile Crescent” in ancient Mesopotamia, and learning from it. Back then, everything that they did was completely organic and yet they still went under. Beginning more than 6,000 years ago (Figure 32), back then, everything was farmed organically. By 4000 B.C., because they did not understand the importance of water quality, their agricultural lands became contaminated with salts. Progressive water-logging and salinity were evident from the historical succession of crops -a 50/50 split of wheat and barley was grown in about 3500 B.C.; by 2500 B.C., salt-tolerant barley represented 80 percent of their crops. By 1700 B.C., wheat could no longer be grown. Centuries of irrigating poorly drained soil with highly mineralized surface water in an arid climate left the land salty and hard. By 1950, sixty percent of the tillable land became salt affected. Another example of this can be found in the western desert of Egypt on the fringe of the Nile River delta. When irrigation began in 1956, within five years, crop lands began deteriorating.

The same scenario is happening here in the United States, particularly in the West where alkaline and saline irrigation waters continue to be applied on existing alkaline soils. As our nation evolved, we started by creating a system of dams, canals, and dikes to gravity flow surface water to irrigate our crops. Later, we began tapping into underground aquifers. Groundwater irrigation wasn't widely used by farmers until drilling equipment, pumps, and ways to power them became available. The world's first electrical irrigation pumping took place in California's Central Valley. In 1902, ground water supplied less than 10 percent of California's irrigated acreage. In 1910, in the Salinas Valley, gravity and river pumping of surface water was still the primary means for irrigation. However, by 1929, the entire region became completely dependent on groundwater for irrigation. By 1940, California drilled and developed about 70 percent of the nation's agricultural wells. By 1950, the state's total irrigated acreage using groundwater increased more than thirty-fold, and accounted for over 50 percent of the total acreage in production at that time. Since then, it has only increased. And like the ancient civilizations before us, we are dying the same “death by a thousand tiny cuts.” However, unlike the ancient civilizations, where it took roughly 6,000 years for enough salt from surface water to render their farm land useless, we are losing the productivity of our farm ground at a much faster rate due to the fact that we are using waters that are significantly lower in quality. In California, where some of the world's most productive farm ground is located, after less than 60 years of irrigation, lands are being retired due to salt accumulation (Figure 33).

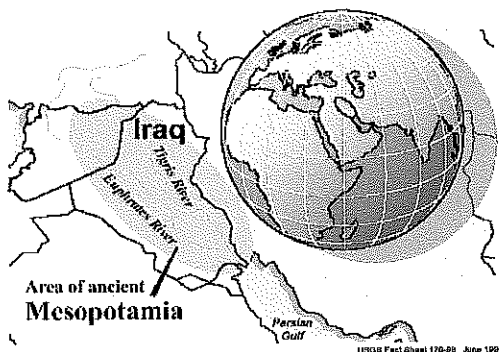


Figure 32. Ancient Mesopotamia



Figure 33. Sodic soil conditions in California's Central Valley

As we become increasingly desperate for a reliable source of cheap water, many farmers have now begun using recycled water supplied from municipal waste water treatment plants. This type of water is, in most cases, worse because it contains a significantly higher amount of alkalinity and salts in comparison to most surface and ground waters. The use of such waters is causing the problem of soil salinity to accelerate at a much faster pace than ever before. When the only water applied to soil was from rain, the soil contained a higher percentage of organic matter, and was fertile because the acidity provided by rain opened more soil

pores and kept them open. This enabled soil microbes to obtain what they needed – to breathe in oxygen and to exchange carbon dioxide. As their population density continued to grow, the soil became more fertile and the acidity within the rainwater kept the soil soft and mellow so that it could be plowed with animals. Now, due to the formation of lime and the hardpan created by the use of imperfect irrigation water, the vast majority of these microbes have been lost through suffocation. Powerful tractors and heavy duty implements are now required to rip and to loosen the soil in an attempt to get oxygen back into it. The loss of these microbes has made it hard to hold the soil together and has resulted in the loss of valuable top soil.

This is why the desire to farm organically is not enough to insure the sustainability of our agricultural ecosystems, because the root of the problem stems from the water that we use. Until the alkalinity of the water is reduced and/or eliminated, the soil will simply reseal again and again, just as it did for the ancient Mesopotamians. Insanity is doing the same thing over and over and expecting a different result. Let us avoid making the same mistake. This is why the importance of understanding water quality, supplying a sufficient amount of acidification, and controlling the pH of a system is so intrinsic to farming. Nature proves that this is so because soil salinity problems exist primarily in arid and semi-arid regions, not high rainfall areas. We need to recognize this. When we do we can then mimic it.

Fourth, the significance of using sulfurous acid is far reaching. This is because if approved, it can help curb the current interest and infatuation with synthetic fertilizers and pesticides and GMOs. How? These inputs are basically attempts to *adapt* to deteriorating agronomic conditions. This is *living* with the problem instead of solving it. The development of salt tolerant plant varieties is a good example of this. Acidification with sulfurous acid does exactly the opposite because it is a strategy that is oriented to solving the *actual* problem. By fixing the root cause and mimicking the acidity of rainwater, it will render the need for synthetic and GMO type inputs unnecessary.

Fifth, when irrigation water cannot infiltrate into soil, it evaporates and becomes wasted, and it requires more irrigation water to be used. When irrigation water is transformed to deliver acidity into the soil, water infiltrates and field capacity increases and the need to irrigate (more often) becomes less. And it will result in a net increase in water savings overall. Understanding water quality and recognizing sulfurous acid's ability to deliver additional acidity into the soil/water solution is perhaps the single most important aspect in the conservation of water. Since agriculture is the largest user of fresh water, use of sulfurous acid will result in producing the biggest breakthrough in water savings we have ever seen.

Sixth, when soil pore spaces become plugged, the soil becomes water-logged and anaerobic, and it is under these conditions pathogens such as E.coli O157:H7 can flourish. Because sulfurous acid has the ability to disinfect the irrigation water and deliver the necessary acidity to reopen and keep soil pores open, it can make the ecosystem within the soil more aerobic and less conducive for pathogens to survive. In addition, when sprinkler irrigating, the bisulfite that will be contained within the irrigation water can also help wash and mildly disinfect leaf surfaces as well, keeping them free of pathogens.

Seventh, the fear and phobia towards sulfur, simply because it is a derivative of crude oil and the refinery process, has caused us to not recognize the vital role sulfur has throughout nature and earth's processes. It is important that we shed certain biases because they have a way of clouding our ability to understand what is real and the truth. When we understand the role volcanoes have in nature, both under the sea and on the surface, and their effect on the oceans, rainwater, and earth's climate, we will undo the many myths and unlock the door to achieving perhaps the single biggest breakthrough in the advancement of humanity – a clearer and more accurate understanding of earth's natural processes and how we must farm. The current organic approach does not recognize the importance of acidification and pH. And it is doomed to fail in arid and semi-arid areas for one simple reason – it offers no practical way for farmers to mitigate the agronomic problems caused by contaminants emanating from their water source. The ability to use sulfurous acid will change all of this because it will give our nation's farmers the ability to amend the irrigation water that they use the same exact way nature does.



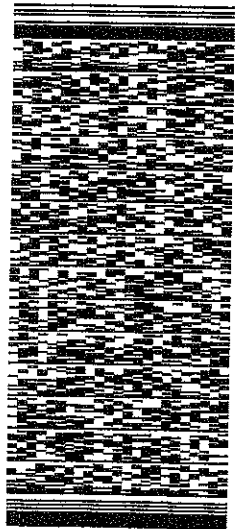
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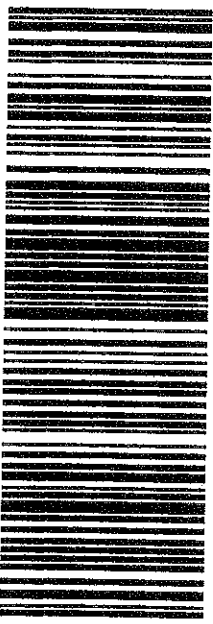


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