Chilean Nitrate

for general use as an adjuvant
in crop production

Executive Summary[1]

The following petition is under consideration with respect to NOP regulations, section 205.602 (h):

Petition: **Annotation to section 205.602(h) be removed such that all crop use of Chilean (sodium) nitrate shall be prohibited in organic agriculture.**

Chilean nitrate is a mined source of highly soluble nitrogen. It is used in agricultural production systems as a fertilizer where traditional methods of cover cropping, rotations, and composting are considered inadequate sources of nitrogen in terms of timing, solubility, and/or form. Currently, the NOP restricts its use to not more than twenty percent of the total nitrogen budget per cropping cycle.

There are currently two petitions submitted to the NOSB pertaining to the use of Chilean nitrate in organic crop production. These two petitions have been considered separately. **This TAP evaluation addresses the petition that requests the exclusion of Chilean nitrate from the National List of substances approved for use in all forms of organic production.**

The TAP reviewers were not in agreement over the general use of Chilean nitrate in organic production. Two reviewers thought it should be removed from the National List, and one reviewer was in favor of a conditional phase-out of the substance whereby time would be granted to acquire reliable information on organic nitrogen fertilizer efficacy or to transition to a new source of nitrogen.

The two reviewers in favor of removal from the National List felt that Chilean nitrate poses a substantial risk of environmental degradation in terms of extraction and use, it use is not generally necessary, and it is counter to the spirit of organic agriculture. One reviewer suggested blood meal, feather meal, and fish powder as possible alternatives to use.

The reviewer in favor of its allowance expressed similar concerns, however the reviewer was also skeptical about the versatility of alternative sources of nitrogen compared with Chilean nitrate. The reviewer emphasized this point in the context of land transitioning from conventional to organic, and also in organic systems incorporating conservation tillage. In these instances, the reviewer felt that whole system benefits would confer greater value on the use of Chilean nitrate.

Summary of TAP Reviewer Analyses

Synthetic/ Nonsynthetic	Allowed or Prohibited	Notes/suggested annotations:
Synthetic (0) *Nonsynthetic (3)*	*Allowed (1)* *Prohibited (2)*	***Reviewer 1:*** *Prohibition of Chilean nitrate from all forms of organic production* ***Reveiwer 2:*** *Continued allowance of Chilean nitrate during a three to five year transition period, conditional upon:* *(a) development of reliable information about nutrient delivery from processed organic fertilizer, or* *(b) another source of predictable available nitrogen is found or devised.* ***Reviewer 3:*** *Prohibition of Chilean nitrate from all forms of organic production*

Identification

Chemical name: Sodium nitrate
Trade name: Chilean nitrate, Bulldog Soda
Other names: Nitrate of soda, Chilean saltpeter, soda niter, nitric acid sodium salt

CAS Number:
sodium nitrate: 7631-99-4

Other Codes:
EPA PC Code: 076104
DOT # NA 1487 Oxidizer
NOES 1983: HZD 69220; NIS 249; TNF 40765; NOS 152; TNE 557740; TFE 110040
EINECS 231-554-3
ICSC #0185
RTECHS # WC5600000
UN #1498
WHMIS: C, D2B

[1]*This Technical Advisory Panel (TAP) review is based on the information available as of the date of this review. This review addresses the requirements of the Organic Foods Production Act to the best of the contractor's ability, and has been reviewed by experts on the TAP. The substance is evaluated against the criteria found in section 2119(m) of the OFPA [7 USC 6517(m)]. The information and evaluation presented to the NOSB is based on the technical evaluation against those criteria, and does not incorporate commercial availability, socio-economic impact or others factors that the NOSB and the USDA may consider in making decisions.*

Characterization

Composition:
sodium nitrate $NaNO_3$

Physical Data:

Melting point:	308°C
Boiling point:	380°C (decomposes)
Specific Gravity:	2.26
Solubility:	Approx. 480 g/L @ 25°C
Stability:	Stable
Hazardous Polymerization:	Will not occur

Properties:
Pure sodium nitrate is an odorless, colorless to light yellow crystalline salt. It is available in synthetic form or from mined sources. The chemical structure remains the same for both cases. The naturally occurring form, known as Chilean nitrate, is derived from *caliche* ore, a crude mineral conglomerate of salts comprised of: nitrates; sulfates; chlorides of sodium; calcium and potassium; magnesium; and various micronutrients including borate, iodate, and perchlorate (Ericksen, 1983). Dissolution is endothermic. The aqueous solution is neutral (Merck 2000).

How Made:
Chilean nitrate is mined from natural deposits of *caliche* ore found in the extremely arid Atacama desert of northern Chile (avg. precip >2mm). These deposits are mined primarily from saline mineral deposits that form veins and irregular masses in the bedrock. The ore is extracted by first drilling or blasting the soil overburden covering the deposits, then transported to the extraction plant. The overburden, usually 1 to 2 m thick, is removed mechanically and left on-site (Collings 1950). During refinement, crushed ore is dissolved at 35°C to extract nitrates, sulfates, potassium, and iodine. Nitrate precipitates are removed, crystallized, dried, and prilled. The purified grade contains at least 97% $NaNO_3$ (Stoddard and Silberman, 1995).

Specific Uses
The material is used as a technical grade nitrogen fertilizer. It can be broadcast, drilled, used as a sidedress, or dissolved and applied as an aqueous solution.

Status

History of Use:
Commercial development of Chilean nitrate deposits first occurred on extremely arid islands off the coast of Chile and Peru around 1840. These island deposits – derived from whole cliffs of seabird excrement, or guano, deposited over thousands of years – were quickly depleted and by 1870 markets turned to more expansive deposits located in the nearby Atacama Desert in northern Chile. These so-called *caliche* deposits are sporadically located in a band 30km wide by 700km long. Unlike the guano deposits, this mined substance is a crude mineral conglomerate of salts possibly formed from nitrogen fixation by microorganisms in playa lakes and associated soils approximately 10 – 15 million years ago (Ericksen 1983). Currently, Chilean nitrate constitutes 0.14% of the total US fertilizer application, and is used primarily by niche markets (Urbansky et al., 2001).

Functionality:
The high solubility of Chilean Nitrate makes it a unique source of nitrate for organic farmers: it is a naturally occurring source of mineral nitrogen, its use does not acidify the soil, and it is highly effective at delivering immediately usable nitrogen to plants. From a purely mineral standpoint, the source and nature of application of Chilean nitrate are analogous to many inorganic materials currently approved for organic crop production, including rock phosphate, potassium sulfate, gypsum, and lime sulfur. Since Chilean nitrate is already in mineral form, there is no need for the substance to undergo the mineralization process. This is especially important in overwintering crops and/or crops grown in cold soils, where judicious application of Chilean nitrate can complement and improve organic nitrogen sources. In areas where crops are grown year-round, organic growers who use Chilean nitrate supplements feel strongly that it is the only viable option for maintaining high quality produce during winter, particularly with respect to leafy greens (Adamchak 2002). Additionally, refined Chilean nitrate is prilled and thus does not require specialized application equipment.

USDA Final Rule:
The USDA final rule lists sodium nitrate for crop production at 205.602(h). It is not allowed for use, "unless its use is restricted to no more than 20% of the crop's total nitrogen requirement" (NOSB 1995). This annotation is derived from a review by the National Organic Standards Board, detailed in Addendum Number 27, as follows:

> The use of Chilean Nitrate (16-0-0) in Organic crop production is limited to not more than 20 percent of total nitrogen supplied to a crop. The producer's Farm Plan shall contain specific provisions and strategies designed to substantially reduce the use of Chilean Nitrate over time. The amount and timing of these reductions will be consistent with documented site-specific constraints. The Farm Plan will seek to explore each and every alternative to the routine use of Chilean Nitrate in the farming system. These alternatives include, but are not limited to: composting, improvement of compost, leguminous cover crops, interplanting, rotations, microbial enhancements, animal manures, varietal selections, planting date alterations, and reducing amounts of applied supplemental nitrogen. The timing and efficiency of Chilean Nitrate applications shall be optimized and documented in the Farm Plan. Certifiers will monitor progress in the reduction of Chilean Nitrate use and will decertify farmers that develop long term dependence on this material. Strong farmer commitment, aggressive action, and measurable results are all necessary elements of this special use of Chilean Nitrate.

Regulatory
U.S. certifiers that prohibit any use of Chilean nitrate include Maine Organic Farmers and Gardeners Association (MOFGA), Northeast Organic Farming Association (NOFA) -New Jersey, NOFA-New York, NOFA-Vermont, NOFA-Massachusetts, and Oregon Tilth Certified Organic. Currently, the Organic Trade Association's (OTA) American Organic Standards recommends that sodium nitrate be phased out by Jan 1, 2003.

International certifiers that prohibit use include the European Union (EU), Organic Crop Improvement Association (OCIA), International Federation of Organic Agriculture Movements (IFOAM), Farm Verified Organic (FVO), National Association for Sustainable Agriculture Australia (NASAA), UN-FAO Codex Alimentarius, and the Japanese Organic Standards (JOS). Producers currently shipping products to Europe or Japan must have their certifiers specifically verify that Chilean nitrate was not used in production.

EPA *Sodium nitrate:* registered under the Toxic Substances Control Act, currently exempt from reporting under the Inventory Update Rule.
Nitrate/nitrite: Clean Water Act, Section 304, 40 CFR 418.32; Safe Water Drinking Act National Primary Drinking Water Regulations; with limits set at 10mg/L NO_3^- -N and 1mg/L NO_2^- -N.

NIEHS National Toxicity Program (NTP) database does not list any regulatory limits for sodium nitrate.

FDA does not regulate sodium nitrate

DOT classifies the substance as a hazardous material, and misuse may increase risk of explosion.

Section 2119 OFPA U.S.C. 6518(m)(1-7) Criteria

1. ***The potential of the substance for detrimental chemical interactions with other materials used in organic farming systems.***

   No information was found detailing adverse chemical interactions with other organic inputs. Nitrate is a highly energetic oxidizer, and hence the substance is generally incompatible with combustible materials and strong reducing agents.

2. ***The toxicity and mode of action of the substance and its breakdown products or any contaminants, and their persistence and areas of concentration in the environment.***

Acute Toxicity:	
Inhalation:	Mild irritant. May cause irritation to upper respiratory tract, headache, nausea, vomiting, dizziness, weakness; may lead to rapid ineffective breathing, cyanosis, loss consciousness, death. Use in well-ventilated area.
Ingestion:	Large doses (15-30 g) fatal, smaller doses may cause gastro-enteritis, headache, abdominal pain, vomiting, muscular weakness, irregular pulse, convulsions and collapse.
Eye Contact:	Mild irritant. Safety goggles if dust is expected or if handling large quantities.
Skin Contact:	Mild irritant. Gloves should be worn when handling.
LD_{50} =	4.3 g/kg (oral, rat)
LD_{Lo} =	200 mg/kg (oral, rat)
LD_{Lo} =	500 mg/kg (oral, human)

Breakdown products/contaminants:
Substance is a naturally occurring, inorganic mineral salt. It has no complex metabolites. Substance is quickly ionized into sodium (Na^+) and nitrate (NO_3^-) in water.

Sodium (Na^+) is persistent in the soil profile in that it is relatively immobile. It tends to accumulate in semi arid and arid environments.

Nitrate (NO_3^-) is highly mobile and tends to leach into groundwater supplies if not used by plants or soil microorganisms. It is a common non-point source water contaminant, particularly in agricultural areas, and is regulated as a contaminant under the Clean Water Act. High nitrate concentrations can be toxic to soil and aquatic organisms. Increases in soluble soil nitrates caused decreases in earthworm populations at Rothamsted (Edwards and Lofty 1975). Nitrate contamination of freshwater streams and rivers in also a concern. One study by Scott and Crunkilton (2000) found ambient levels of surface water nitrate in areas of intensive agricultural cultivation to be toxic to channel catfish, *Ceriodaphnia dubia*. Nitrates have also been linked to numerous human health issues.[2]

3. The probability of environmental contamination during manufacture, use, misuse, or disposal of the substance.

Potential environmental impacts stem from point source pollution at mining sites, and non-point source pollution in areas of Chilean nitrate application.

The extraction and processing of Chilean nitrate has adverse ecological consequences. Information on Chilean *caliche* mining operations is scarce, but general conditions are assumed to be no better than those in the United States. The extraction of nitrates from northern Chilean deserts has caused serious environmental damage through the removal and concurrent dumping of sand and rock tailings (Muniz 1996). Primary concerns are soil degradation due to excavation of overburden, leaching of tailing piles, health risks to mine workers, contamination of downstream water sources due to increase sediment and nitrate load, and air pollution due to extracting/processing activities. In 1994 the Chilean government passed one of the more complete and strict environmental laws in the Americas, with two Articles of the law directed specifically at the mining industry. Remarkably, the Ministry of Mining took the position that sustainable development of mining operations is necessary in order to ensure investment security (Muniz 1996). No further information is available about the effectiveness of this legislation. Currently, nitrate extraction totals over 900,000 tons year^{-1}, of which 75,000 tons year^{-1} is sold to US farmers (Urbansky et al. 2001).

The high solubility of Chilean nitrate virtually ensures that any nitrate not immediately assimilated by plants or soil organisms will leach down the soil profile and potentially enter the water table. The extent to which this happens is dependent on the balance that exists between the biological demand and the active pool of available nitrogen in the system. Nitrates are not locally persistent, and are quickly utilized, leached, or denitrified. Point-source nitrate contamination due to application will vary greatly depending on soil type, biological nitrogen demand, and depth to the water table. Contamination due to sodium buildup will depend upon timing of application and potential evapotranspiration.

4. The effects of the substance on human health.

Extraction and application of sodium nitrate for agricultural purposes has possible detrimental human consequences.

Nitrate contamination. In the absence of an adequate biological nitrate demand, nitrates have a high leaching potential and commonly migrate into groundwater sources. Nitrate *per se* is not of particular concern to human health. However, nitrate in the human body is endogenously reduced to nitrite, which has been linked to methemoglobinemia, a potentially fatal condition whereby nitrites interfere with oxygen uptake (Kross et. al, 1992). Medical complications due to exposure to nitrate-containing substances have resulted from absorption though burned skin (Harris 1979) and ingestion (Grant 1986). Nitrites can be further reduced to nitrosamines. These compounds are some of the strongest known carcinogens (NAS 1981), can act systemically (Tricker et al. 1991), and have been found to induce cancer in a variety of organs in more than forty animal species, including higher primates (Bogovski and Bogovski 1981). A recent study of contaminated municipal drinking water in rural Iowa linked nitrates to a higher risk of bladder cancer in older women (Weyer et al. 2001). Elevated nitrate concentrations may also increase the incidence of non-Hodgkin's lymphoma (Weisenburger 1991; Ward et al. 1996). In California, nitrates are the largest non-point source pollutant, with levels frequently exceeding drinking water standards (USGS 1998).

[2] *See* Effects on Human Health, *below.*

Residual contaminants The chemical composition of an average *caliche* deposit is difficult to estimate due to localized variations in relative amounts of saline constituents. The measurements at left were based on monthly combined averages from the two largest extraction plants in the Atacama desert (Grossling & Ericksen, 1971). According to the packaging, a bag of fertilizer grade Chilean nitrate[3] was composed of the following:

$NaNO_3$	98.11%
NaCl	1.11
Na_2SO_4	0.41
H_2O	0.1
H_3BO_4	0.1
$KClO_4$	0.09

Average content of ionic saline constituents in mined caliche

ion	%
SO_4^{2-}	10
Na^+	6.9
NO_3^-	6.3
Cl^-	4.6
Ca^{2+}	1.8
K^+	0.7
Mg^{2+}	0.5
$B(OH_4)^-$	0.5
IO_3^-	0.06
ClO_4^-	0.03

During processing, the dissolution process homogenizes impurities. Among these constituents, perchlorate is of particular concern. At sufficiently high concentrations, perchlorate interferes with iodide uptake in the thyroid gland (EPA 1998, Clark 2000). Since 1997, perchlorate contamination has been discovered in a number of US water supplies, prompting the EPA to add it to its Contaminant Candidate List (CCL, Perciasepe 1998) and the Unregulated Contaminants Monitoring Board (UCMR; Browner, 1999). The ecological impact of perchlorate is not well known. While perchlorate contamination in potable water is difficult to treat (Urbansky & Schock 1999), microbes capable of reducing the anion appear to be abundant (Logan 1998, Coates et al. 1999, Nzengung & Wang 2000). Preliminary risk assessment has focused on quantitative analyses to determine perchlorate content in fertilizers. Current analyses put perchlorate anion concentrations at 0.5-2 mg g^{-1} of sodium nitrate derived from *caliche*. However, a recent letter to the EPA from SQM North America, the sole source of Chilean nitrate, indicated that SQM had modified its refining process to produce fertilizer containing less than 0.01% perchlorate (0.1 mg g^{-1}). The same report indicated that since Chilean nitrate accounts for only 0.14% of US fertilizer application, it cannot be considered a significant anthropogenic source of perchlorate nationwide (Urbansky et al., 2001). Noting that the use of this fertilizer is highly localized in some areas, the authors indicate the need for further research into guidelines for application rates that are relevant to site-specific watersheds or ecosystems.

5. *The effects of the substance on biological and chemical interactions.*

Nitrates are a necessary plant and animal nutrient, but can be toxic to both at high levels. The carbon:nitrogen ratio of a soil ecosystem affects in part the mineralization rate of organically bound nitrogen. Typically, nitrogen is the limiting factor. Additions of soluble nitrogen increase carbon mineralization rates, which may lead to a decrease in soil organic matter.

Salt accumulation. Salinity stress is one of the major causes of historical and modern agricultural productivity losses throughout the world due to its interference with osmotic regulation of water and nutrients. One of the limiting factors in the use of sodium nitrate is its high potential to increase soil salinity. Sodium nitrate is the benchmark substance for the Salt Index: it has a rating of 100, highest of all organically approved adjuvants (Rader et al. 1943). Unlike nitrate, sodium is locally persistent. Soil has a net negative charge owing to the molecular orientation of clay surfaces and organic matter. Thus, it binds positively charged cations, like Na^+, much more strongly than it does negatively charged anions, such as NO_3^-. Hence, sodium is not prone to leach from the soil profile, nor is it taken up by plants in appreciable amounts. In addition to raising soil pH and decreasing productivity, the accumulation of sodium leads to destruction of soil structure through breakdown of soil aggregates. This results in severe drainage problems that exacerbate sodium accumulation. The effects are hastened in areas where low rainfall, high evaporation, and poorly drained soils inhibit leaching and promote the accumulation of salt from incoming water. Semi-arid environments and irrigated systems are at highest risk. In most cases, salt-related constraints are more costly to remedy and control than are nutrient deficiencies (Singer & Munns 1987). Sodicity effects can be partially offset by increasing soil organic matter inputs which the soil's capacity to bind Na+ in a manner that does not adversely affect soil structure.

Fertilizer burn may occur due to excess nitrate uptake. Iwabuch et al. (1978) reported that heavy applications of Chilean nitrate was a cause of severe crown rot in onion bulbs.

Increases in pest susceptibility may occur due to higher than average nitrate concentrations in plants. Kowalski and Visser (1979) found that imbalances in proteins due to high soil N corresponded to more severe aphid infestations than crops which were not fertilized with Chilean nitrate.

Inhibition of nitrogen-fixation. Organic agricultural systems commonly rely on nitrogen-fixing legumes to maintain soil fertility, increase organic matter content, and improve soil structure. When plant available nitrogen is high, N-fixation processes are inhibited. Excess NO_3^- concentrations in the soil resulting from applications of sodium nitrate potentially reduce N-fixation processes, resulting in a decrease in cover crop productivity (Sylvia et al. 1999). This is only a consideration where use is concurrent with cover cropping.

[3] 50lb bag, Peaceful Valley Farm Supply, Grass Valley, CA.

6. Alternatives to using the substance in terms of practices or other available materials.

There are few organically approved alternatives that are as versatile and as soluble as Chilean nitrate. As described previously, the fact that the material provides an readliy available source of mineral nitrates gives it a distinct advantage over organically complexed nitrogen sources. Timing and/or market constraints may limit the use of composting and cover cropping and increase the need for fertilizing with sources of highly soluble nitrogen. This is especially true in intensively farmed organic systems on high value land. By comparison, cover cropping and composting offer significantly lower nitrogen inputs by weight.

While there are a number of soluble nitrogen fertilizer sources approved for organic production, little information exists on effective management of these materials. Specifically, optimum form and timing of application is lacking. Most soil nitrogen derived from compost or green manures is depleted eight to ten weeks after application (Gaskell 1999, Hartz et al., 2000). Smith (1992) determined that the nitrogen release curve for a combined cover crop/feather meal amendment was inadequate to supply late-season nitrogen demand in bell peppers. In addition, variability in composition of organic fertilizers is a serious problem limiting their efficient use (Gaskell 1999), as are solubility and pH control when used in drip systems (Peet 2002). Nonetheless, there are a number of substances that are often used to provide supplemental, readily usable nitrate-nitrogen. These substances are commonly applied in intensively cropped systems or as a post-cover crop amendment. A short list is presented below. In addition to these substances, improved management of organic matter, increasing biological activity, and suitable crop selection may also aid in increasing N availability.

Material	Manufacturer / Source	Advertised Analysis	Cost / lb N
Bloodmeal	Peaceful Valley	(14 - 0 - 0)	$4.30
Pelleted Chicken Manure	Integro	(3.5 – 1 – 7)	$6.50
Fish Meal	Peaceful Valley	(10 – 6 – 2)	$5.50
Liquid Fish	EcoNutdent	(3.4 – 2 – 0.5)	$6.00
Phytamin 800	Peaceful Valley	(7 – 0 – 0)	$7.50
Feather Meal	Calif. Organic Fertilizers	(7 – 1 – 7)	$5.50
Seabird Guano	Verditech	(11 – 8 – 2)	$6.25
Chilean nitrate	Dirt Works	(16 - 0 - 0)	$3.00

Adapted from Gaskell, 1999

7. The compatibility of the substance with a system of sustainable agriculture

Sodium nitrate is a non-renewable resource. Its compatibility with sustainable agriculture rests on reducing the likelihood of toxic effects of nitrates, and potential soil degradation due to salt accumulation. Nitrate leaching is predicated on applications of soluble nitrogen in excess of biological demand. The effects range from fertilizer burn to soil organism toxicity to off-site contamination. Where leaching into groundwater occurs, the impacts of nitrate contamination on aquatic wildlife and human health are a proven concern. Judicious applications of Chilean nitrate, combined with inherently higher microbial activity and soil organic matter found in organic systems, may be adequate to mitigate off-farm consequences.

In the case of some high value, cool weather crops, traditional organic inputs may be inadequate at supplying soluble nitrogen throughout the growing season. Chilean nitrate amendments can be used to supplement organic systems in cold soils, soils with poor drainage, and intensively farmed crops. However, measured or perceived benefits of Chilean nitrate-nitrogen must also be balanced against potential impacts on crop productivity and soil quality due to salt additions. Irrigated systems in arid and semi-arid climates are at higher risk, and require additional water inflows to correct. Areas with adequate rainfall are not as adversely affected, and increased soil organic matter may also help offset sodicity effects.

Sodium nitrate is generally not approved for use by organic farmers outside the US, a position shared by many domestic organic farming associations. A report by IFOAM that restricts use of Chilean nitrate indicates that its use by growers is often predicated not on the substance being inherently "natural", but rather it is used because of a perceived lack of alternatives or insight into a grower's farm operation (IFOAM 1989). There are numerous alternative sources of soluble nitrogen but these alternatives are generally not as efficient due to lower concentrations of soluble N, lower solubility, and a lack of information about best management practices. Nonetheless, the "twenty percent" rule[4] indicates that Chilean nitrate amendments should be temporal until such time as management of organic inputs makes its use superfluous. It further states that growers who develop a dependence on the substance will be decertified, thus bringing into question the intent of the NOSB when it decided to allow limited use. Currently, there are no industry-specific prohibitions/allowances pertaining to use of a given substance.

[4] See NOSB National List final rule, Addendum 27, above.

Tap Reviewer Discussion

Contractor's note: The following responses have been reprinted verbatim.

Reviewer 1 *[West coast, Ph.D. in Horticulture, 19 years experience as Extension Vegetable Specialist in Texas and California, specialization in nutrient and irrigation management]*

The product sold today as Chilean nitrate is distinctly different from the original seabird guano originally bearing that designation; indeed, guano is still available today, but is substantially more expensive, hence the interest in sodium nitrate. The low grade ore currently being mined requires substantial processing, and generates considerably more tailings than finished product; one must assume that the exploitation of these deposits involves substantial environmental cost. Use of this product seems counter to the basic philosophy of organic agriculture. Also, given the provenance of this product, it is not clear to me why it should be acceptable for use, while chemically similar products that are also mined, then refined (potassium nitrate, for example) are banned.

From the standpoint of effects on the soil system, sodium nitrate is less desirable that either potassium nitrate or calcium nitrate. As a monovalent cation, sodium is a deflocculating agent, and unlike potassium is not required in significant amounts by crops. Much is also made about the high salt index of sodium nitrate, but application of this product at the levels allowed under section 205.602(h) presents little risk in either of these regards. In the eastern U.S. annual rainfall is generally sufficient to maintain salt balance, and in the West the amount of sodium applied in this fertilizer pales in comparison to that contained in most irrigation waters. Also, organic soil building practices generally provide sufficient organic matter to maintain good soil tilth.

If used in moderation, none of these nitrate-containing materials would have serious detrimental effects on the soil biota. The presence of significant quantities of nitrate in organically managed soils is not unusual; following the breakdown of a legume cover crop, a buildup of 10-20 mg kg^{-1} NO_3-N is common. Manure-based compost may also introduce substantial nitrate; NO_3-N concentration > 100 mg kg^{-1} is not unusual. Off-site movement of nitrate from organically managed fields can occur, particularly when irrigation is inefficiently managed. Therefore, the use of a nitrate-containing fertilizer does increase the pollution potential. However, the cost of sodium nitrate is sufficiently steep to minimize the risk of application in excess of crop demand.

It is true that application of this product late in the crop cycle of leafy greens (the expected use pattern) would increase the nitrate concentration of the produce, but it would be very unlikely to result in levels deemed a health hazard by current standards. In my research on conventionally grown lettuce produced in the Salinas Valley, I have never found nitrate levels in the edible portion to exceed the standards set by the European Community, even in field situations where excessive amounts of synthetic fertilizer was used. Other researchers have found that conventionally produced California spinach occasionally exceeds these standards, but the likelihood of any organic production, even with the use of sodium nitrate, approaching or exceeding these standards is remote

I do not agree with the contention that use of sodium nitrate is required on organic vegetables grown during cool portions of the year; obviously, many organic organizations agree with me. In California winter production along the central coast it is challenging but not impossible to provide sufficient N fertility organically. A number of organic growers in this region attempt vegetable production with only infrequent use of cover cropping, the foundation of successful organic N fertility management. This is done because the time required to grow the cover crop takes away from cash cropping opportunities. They rely more on the application of organic amendments (composts, fishery wastes, etc.), and use sodium nitrate to cover the shortfall. This approach, while economically understandable, is not really in keeping with the organic philosophy.

Even growers who use cover cropping appropriately may have trouble maintaining N sufficiency in some cropping situations, but there are alternatives to sodium nitrate. These situations can be handled in other ways, such as utilizing wider plant spacing to reduce competition for N, and substituting another product for sodium nitrate. I have compared the rate of N mineralization of a number of organic fertilizers; while none are as readily available as sodium nitrate, several common materials (blood meal, feather meal, and hydrolyzed fish powder, for example) have quite rapid rates of mineralization (as well as initially containing substantial amounts of mineral N). With adequate planning the use of these products is an appropriate alternative to sodium nitrate application.

In summary, the risks associated with the use of sodium nitrate are minimal, but its sourcing is problematic, its use encourages management practices not in keeping with the organic philosophy, and suitable alternatives to that use are available.

Recommendation: **Petition should be granted, prohibiting the use of this product in organic production.**

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Reviewer 2 *[West coast, Ph.D. .in Crop and Soil Science, specializing in soil fertility and sustainability of managed and natural ecosystems; carbon and nitrogen cycling processes]*

Evaluation of the Petition against the Organic Farming Production Act Section 2119 U.S.C. 6518(m)(1-7) Criteria:

1. *The potential of the substance for detrimental chemical interactions with other materials used in organic farming systems.*
   In the manner it is used in organic production practices, minimal detrimental chemical interactions should occur. The nature of these interactions will be minimal. This assumes all precautions are taken for transport and storage of the material to and on the site.

2. *The toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment.*
   Excessive nitrate (NO_3^-) loading in soils can lead to leaching into groundwater supplies if not used by plants or soil microorganisms. It is a common non-point source water pollutant, particularly in agricultural areas. High nitrate concentrations as well as low chronic levels in aquatic systems can be toxic to aquatic organisms. Nitrates have also been linked to numerous human health issues. Applications of Chilean nitrate using best management practices should avoid environmental contamination.

3. *The probability of environmental contamination during manufacture, use, misuse, or disposal of the substance.*
   I am unfamiliar with the mining operations for Chilean sodium nitrate and therefore cannot give an appropriate response. Assuming that the Chilean sodium nitrate production is no different that conditions in the United States, there will be environmental impact at the mining site, production facility and during transport and storage. The use of water to manufacture the nitrate suggests potential movement of nitrate to groundwater and surface water at the mining site. However the magnitude of nitrate loss cannot be determined with the information supplied.

   After production, storage and transportation may become issues. However, since Chilean nitrate is in a dry form it reduces the risk of environmental contamination during transport and storage. Misuse through over application could lead to environmental contamination through leaching of nitrate to ground water and through gaseous emissions of greenhouse gases. Since the product is intended for use, no disposal issues would be anticipated.

4. *The effects of the substance on human health.*
   Most of the constituents stated in the analysis should not be a problem, except possibly boron. Boron health effects are not well researched. Boron studies normally examine the benefits of increasing uptake. Over the United States, atmospheric concentrations of boron average about 0.5 ng/m3 of air. Boron concentrations in the surface waters of the United States average less than 0.3 mg/l, but can range as high as 15 mg/l in regions draining boron-rich soils. A survey of 100 U.S. drinking water supplies showed a median boron concentration of 0.03 mg/l. In foods, boron ranges from a low of 0.16 µg/g dry weight in red meat to about 160 ppm in quince. The average U.S. diet contains 2.5 to 3 µg/g of boron and provides a dietary intake in humans of about 1.5 mg boron/day.

   The perchlorate content in of the Chilean sodium nitrate fertilizer is the other potential concern. However, the petition states that changes in the manufacturing processes have lead to less perchlorate content of the finished product. The soil microbial community should easily process the low level of perchlorate. Overall the low level of perchlorate should not pose human health problems at the recommended application rate.

5. *The effects of the substance on biological interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including salt index and solubility in the soil (crops, and livestock).*
   Soils with a high level of boron may become impacted through the addition Chilean nitrate. Legumes – especially dry beans – may be adversely impacted if boron levels increase in boron impacted soils. Sustained or excessive use of Chilean nitrate may affect soils impacted by salinity. Chilean nitrate contains sulfate, chloride, sodium and other cations than can lead to soil salinity. However, since current guidelines establish that Chilean nitrate application can not exceed 20% of N application this should minimize salinity problems. However, as mentioned some soils and crops could be impacted by the sustained use of Chilean nitrate. Standard soil analysis for salinity and sodicity should be performed on susceptible soils.

6. *The alternatives to using the substance in terms of practices or other available materials.*
   Few available if any organic nitrogen sources would behave as Chilean sodium nitrate does in organic production systems. Most organic sources of nitrogen have low nitrogen content. In addition, nitrogen is often in an organic form. Alternatives to Chilean nitrate range from compost, manure, fish products and covercrops. Organic nitrogen needs to be mineralized by the soil microbial community to become available for crop uptake. Predicting the mineralization of organic nitrogen sources has been challenging. Supplementing fertilizers regimes with an available source of nitrogen such as Chilean nitrate can remove some of the guesswork in delivering nutrients to crops. With that being said, there are examples in the literature where organic systems use only manure and cover crops to give similar yields to conventional systems. However, these yields are often only achieved after 3 to 5 years of alternative management. Supplementing

with Chilean nitrate during the conversion from conventional to alternative agricultural could be a temporary use of the mined nitrate source.

There are other reasons for keeping the Chilean nitrate source in organic agriculture. Reduced tillage systems are currently being considered and would benefit all types of agriculture. Converting organic agriculture to reduced tillage would be difficult without a readily side-dressable form of nitrogen fertilizer. Composts and manures are difficult to sidedress with current technology. Chilean nitrate has similar physical properties to conventional nitrogen fertilizer preparations and therefore make it amendable to be sidedressed. This would be especially important in vegetable row crop systems.

7. *Its compatibility with a system of organic agriculture.*
Organic growers currently have limited types of fertilizers that can be used. Most are organic based and therefore their nitrogen availability is often difficult to predict. This will continue to be a problem. The use of smaller amounts of mined nitrate to sustain production seems logical until nutrient release from more processed organic fertilizers can be better predicted. However, the supply of natural nitrate is limited and will eventually be exhausted. More intensive efforts to mine remaining supplies may lead to environmental problems. Many organic certifying organizations are currently in the process or have already disallowed the use of mined nitrates. It seems inevitable that that an alternative source of fertilizer N with predictable nitrogen release characteristics will have to be found.

Conclusion:

I suggest that mined nitrates be kept on the List for a period of transition until the reliability of nutrient delivery from processed organic fertilizers can be determined or another source of predictable available nitrogen is found or devised. I suggest a cooling off period of 3 to 5 years to reduce the dependency on mined nitrate.

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Reviewer 3: *[Organic Vegetable grower, 20 years experience; Doctoral candidate in Environmental Studies, specializing in history and sociology of alternative agriculture]*

- **Evaluation Against Criteria**

1. *The potential of the substance for detrimental chemical interactions with other materials used in organic farming systems.*
not applicable

2. *The toxicity and mode of action of the substance and of its breakdown products or any contaminants, and their persistence and areas of concentration in the environment.*
As noted, use of Chilean nitrate tends to leave a residue of sodium that could be problematic over the long run. But the most important concern is the transport of excess nitrate into the water table, thus leading to potential downstream contamination.

3. *The probability of environmental contamination during manufacture, use, misuse, or disposal of the substance.*
Chilean nitrate is a mined substance. The mining process itself creates environmental degradation. Byproducts of the mining and processing can be sources of pollution. In agricultural systems, excessive use can lead to non-point source pollution of water table.

4. *The effects of the substance on human health.*
There would seem to be strong potential for danger to human health if this substance contacted food or water supplies in high enough concentrations.

5. *The effects of the substance on biological interactions in the agroecosystem, including the physiological effects of the substance on soil organisms (including salt index and solubility in the soil (crops, and livestock).*
This is a particularly important concern. As the foundation of any organic production system, the health of the soil should be of paramount concern. Chilean nitrate has the potential to cause adverse effects to soil flora and fauna; inappropriate use could quite easily lead to decline of quality and quantity of soil organic matter.

6. *The alternatives to using the substance in terms of practices or other available materials.*
In soil systems there are abundant alternatives and I see no reason for allowing Chilean nitrate in organic production, even restricted to 20% of a crop's total nitrogen.

7. *Its compatibility with a system of organic agriculture.*
Given the points mentioned above, it is my opinion that Chilean nitrate is not compatible with organic agricultural systems. Even the production of leafy greens during the off/cold season, can be accomplished via other means, albeit not without considerable skill and effort.

- **Concluding Remarks**

Competent organic growers will have a fertility program and soil husbandry practices in place that should make resorting to Chilean nitrate unnecessary. If additional nitrogen appears to be needed for a particular crop in a certain situation, abundant alternatives exist.

- **Specific Recommendations**

The substance in question should be **removed** from the National List.

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