Aquatic Plant Extracts

Crops

Identification of Petitioned Substance

Chemical Names:
Not applicable

Other Names:
Kelp extracts

Trade Names:
Alg-A-Mic
Stress-X Powder
Acadian™ Organic Powder 0.5-0.3-14 (OMRI, 2005)

CAS Numbers:
84775-78-0 (Extracts of *Ascophyllum nodosum*)

Other Codes:
None

Characterization of Petitioned Substance

__Composition of the Substance__:

Aquatic plant extracts are composed of chemicals naturally found in aquatic plants, as well as breadkdown products that are formed during the manufacturing process. Common sea plants identified in the literature as sources of aquatic plant extracts include knotted wrack (*Ascophyllum nodosum*) and Sea Bamboo (*Ecklonia maxima*) (NCR, 2004). Aquatic plant extracts used as soil amendments are most commonly derived from kelp, specifically from *Ascophyllum* spp. and other seaweed harvested from the North Atlantic (Baldwin, 2001).

Specific chemical ingredients are not listed in product information available for most commercial aquatic plant extract products. However, aquatic plants contain proteins, lipids, sugars, amino acids, and nutrients, vitamins, plant hormones, and other biochemicals. A laboratory analysis of liquid aquatic plant extracts, provided by Laboratoires GOEMAR (undated) as an attachment to the Original TAP Database Form (1995), listed the following substances as components of aquatic plant extracts:

- **Amino Acids:** glutamic acid, alanine, aspartic acid, methionine, glycine, ethanolamine, lysine, cystine, threonine, serine, praline, phenylalanine, valine, leucine, isoleucine, argenine, tyrosine,

- **Vitamins:** carotene, fucoxanthin, thiamine (B1), riboflavin (B2), pantotenic acid, niacin, B12, C, D3, E, K

- **Phytohormones:** glycosyl cytokinins, auxins and gibberellins

- **Other components**: polysaccharides (i.e., complex sugars), betaines[1]

Kelp contains a wide range of naturally occurring plant nutrients and trace minerals essential to plant growth, health, and productivity. Aquatic plant extracts also contain carbohydrates (e.g., alginic acid and mannitol) that bind micronutrients and help make them more available to crop plants. These components of aquatic plant extracts also contribute to building soil structure (Acadian Seaplants Limited, Undated).

Cytokinins, a class of plant hormones present in aquatic plant extracts, have been reported to have beneficial effects on crops, including increase in number or size of fruits or seed heads, synchronization of flowering within a field, and delayed decay of mature plants (Baldwin, 2001; Baker, 1996). When used as a plant dip, cytokinins

[1] Many plants use betaines to regulate and maintain osmotic pressure in their cells. This allows the plant to achieve tolerance to water shortages or heavy salt stresses (Nishimura et al., 2001).

may also reduce transplant stress (Hall, 1997). Although other plant hormones (e.g., auxins, gibberellins) are present in aquatic plant extracts (Allen et al., 2001; Baker, 1996), they are not likely to be present in concentrations sufficient to have noticeable effect on plant growth (Baldwin, 2001). For this reason, some marketed products may be enhanced with synthetic hormones to ensure performance of the product (Baldwin, 2001).

Properties of the Substance:

Aquatic plant extracts are described as a brownish-black powder or brown liquid with a mild marine (or fish) odor (Original TAP Database Form, 1995; Necessary Organics, 1991). The material is soluble in water and ethanol, is stable, and is not subject to hazardous polymerization (Original TAP Database Form, 1995; Necessary Organics, 1991). It is non-flammable (Necessary Organics, 1991).

Specific Uses of the Substance:

According to the Original TAP Database Form (1995), aquatic plant extracts are used as foliar fertilizers (on all crops) or as soil conditioners. Aquatic plant extracts also are used in combinations as a foliar/soil feed or transplant solution and seed treatment. The material is then absorbed into the plant and acts as a growth promoter. Aquatic plant extracts can be used as a source of micronutrients and growth promoters; as a rooting solution for transplants and cuttings; for cold hardiness in tomato plant, citrus fruits, and cabbage; and to reduce pest damage (nematodes in tomato and okra; mites in strawberries, peaches and apples) (Original TAP Database Form, 1995).

Aquatic plant extracts are sometimes applied as a foliar spray by farmers seeking a natural source of micronutrients. For the most part, none of the micronutrient levels in kelp extracts are high enough to correct a deficiency, but they are used as a "tonic" providing a broad array of micronutrients and other trace elements in organic farming (Hall and Sullivan, 2001). Some aquatic plant extract products are supplemented with synthetic nutrients (Hall and Sullivan, 2001).

Approved Legal Uses of the Substance:

National Organics Program (NOP)

Aquatic plant extracts (other than hydrolyzed) are currently on the National List for use as a plant or soil amendment. Annotations to the National List limit the allowable extraction process to those using potassium hydroxide or sodium hydroxide solvents, and the solvent amount used is limited to that amount necessary for extraction. Extraction processes are described further in Evaluation Question #1.

EPA

Extracts of *Ascophyllum nodosum* (CAS number 84775-78-0) are on EPA's list 4B of inert ingredients in pesticides.

EPA exempted cytokinin in aqueous extract of seaweed meal (as opposed to seaweed extract) from the requirement for a tolerance in all food commodities when used as a plant growth regulator on plants, seeds, or cuttings and on all food commodities after harvest (EPA, 1998).

Action of the Substance:

As previously mentioned, aquatic plant extracts are used as foliar fertilizers or as soil conditioners. An understanding of the mechanisms of action that produce the beneficial effects of aquatic plant extracts is incomplete (Henry, 2005). Research has demonstrated that many crops do not respond to seaweed extract when soil fertility and production conditions are favorable (Kuisma, 1989; McGeary and Birkenhead, 1984). Other studies have shown that crops are more likely to respond to kelp products under stressful growing conditions (Verkleij, 1992; Nelson and Van Staden, 1984; Abetz, 1980). However, a study in 1995 found no beneficial effects to tomatoes of kelp-derived foliar sprays when the plants were inadvertently subjected to stress early in growth (Tourte, 1997).

Foliar fertilization is subject to variables associated with (1) uncertainty and variability of nutrient content of material sprayed and (2) leaf uptake processes (Tourte, 1997). More specifically, the product efficacy may be influenced by the particular species used to make the extract, the growth stage of the plants, the time of harvest and post-harvest handling of the plants used in the product, the processing method, and the product's shipment and storage conditions (Henry 2005). Effectiveness of kelp extracts probably varies with crop type, quality of the foliar spray itself, soil nutrient availability, timing of spray applications, and soil moisture and weather conditions. For some crop and/or conditions, foliar treatment with kelp products may have no effect (Tourte, 1997).

Aquatic plant extracts used as a soil amendment improve soil fertility by making nutrients and hormones more directly available to plants. Aquatic plant extracts contain carbohydrates such as alginic acid and mannitol, which enable plants to better absorb nutrients from the soil. The carbohydrates are broken down resulting in the stimulation of beneficial soil bacteria that fix nitrogen making it available to plant roots. Furthermore, these activities decrease the need for chemical fertilizers (Smittle, 1991).

Additionally, hormones (e.g., auxins, cytokins, and gibberellins) contained in plant extracts are absorbed into the plant and act as growth promoters. When used as a plant growth regulator, seaweed extract would be expected to alter cell division, root and shoot elongation, initiation of flowering, and other metabolic functions (in contrast to fertilizers, which simply supply minerals needed for nutrition) (Allen et al., 2001).

Status

International

Canada - Canadian General Standards Board (CGSB) -
http://www.pwgsc.gc.ca/cgsb/032_310/32.310epat.pdf

As of June 2004 draft (CGSB, 2004), aquatic plant extracts were accepted for use in Canada if they were natural (nonsynthetic). The only synthetic solvents allowed for extraction are potassium hydroxide or sodium hydroxide, which are not to exceed the amount necessary for extraction. If the product contains other synthetic preservatives (e.g., formaldehyde) or is fortified with otherwise prohibited plant nutrients, then the aquatic plant product is prohibited in Canada.

CODEX Alimentarius Commission - ftp://ftp.fao.org/docrep/fao/005/Y2772e/Y2772e.pdf

Based on Table 1 of the CODEX, substances for use in soil fertilizing and conditioning - seaweeds and seaweed products - need recognition by the certification body or authority.

European Economic Community (EEC) Council Regulation 2092/91 –
http://europa.eu.int/eur-lex/en/consleg/pdf/1991/en_1991R2092_do_001.pdf

Aquatic plant extracts are allowed in the EU, following Annex IIB – Seaweed and seaweed products (Organic Trade Association, 2002).

Seaweeds and seaweed products are allowed for use as fertilizers and soil conditions, as far as directly obtained by:

- Physical processes including dehydration, freezing and grinding;
- Extraction with water or aqueous acid and/or alkaline solution; and
- Fermentation;

Need recognition by the inspection body or inspection authority.

Japan Agricultural Standard for Organic Production— http://www.ams.usda.gov/nop/NOP/TradeIssues/JAS.html

No information pertaining to aquatic plant extracts was located at this site.

California Certified Organic Growers International (CCOF) – http://www.ccof.org/pdf/GlobalMarketAccessDraftForReview.pdf

No information pertaining to aquatic plant extracts was located at this site.

Washington State Department of Agriculture: European Organic Verification Program (EOVP) – http://agr.wa.gov/FoodAnimal/Organic/default.htm

No information pertaining to aquatic plant extracts was located at this site.

Evaluation Questions for Substances to be used in Organic Crop or Livestock Production

Evaluation Question #1: **Is the petitioned substance formulated or manufactured by a chemical process? (From 7 U.S.C. § 6502 (21))**

Alkali Extraction of Aquatic Plant Extracts:

According to the Original TAP Database Form (1995), seaweed extract is produced from fresh, live plants which are processed into a soluble powder or liquid, and may be stabilized with synthetic acids and fortified with other ingredients.

Aquatic plant extract manufacturers utilize an alkali extraction process to "digest" the plants and derive both micronutrients and naturally occurring plant hormones from plant sources. This process also transforms the plants into a soluble, easily transported form. The majority of manufacturers use potassium hydroxide as the primary reagent in the alkali extraction process. Other alkali reagents used by some manufactures include sodium hydroxide, calcium hydroxide, and sodium carbonate (Henry, 2005).

Alkali extraction may be conducted either at ambient or elevated temperatures and pressures. Some manufacturers claim that there is a reduced yield of desired plant growth hormones when the products are extracted at higher temperatures. However, no studies have been found comparing the effectiveness of extracts produced at different concentrations of alkali, or at different temperatures (Henry, 2005).

Following alkali digestion, most manufacturers reduce the pH of the product with an acid, most commonly phosphoric acid (Henry, 2005). Phosphoric acid is a synthetic material (Original TAP Review, 1999). Only the amount of acid needed to achieve a pH of 3.5 is recommended (Conrad, 2002). It is not clear if neutralization is a necessary step. One form of the most widely-used extract product (Maxicrop) is not neutralized, and a 25 percent solution has a pH of 9-10. No studies have been found comparing the effectiveness of high-pH versus neutralized alkali extracts (Henry, 2005).

Nonsynthetic Production of Aquatic Plant Extracts

According to the Original TAP Database Form (1995), aquatic plant extracts can also be derived naturally. For example, kelp can be dehydrated after harvest by sun drying, and then ground into a meal product. This kelp meal can be sprinkled directly on the soil , or diluted with water and either sprayed on plant foliage as a foliar spray or poured directly into the ground as a soil drench (3R Lighting, 2005). Nonsynthetic products also may be produced using mechanical disruption, or freezing, pulverization, and clarification of the thawed slurry (Henry, 2005). The relative efficacy of alkali-extracted versus non-alkali-extracted product has not been consistently demonstrated, perhaps partly as a result of a lack of understanding of the mechanism by which aquatic plant extracts exert any purported beneficial effect (Henry, 2005).

<u>Evaluation Question #2:</u> Is the petitioned substance formulated or manufactured by a process that chemically changes the substance extracted from naturally occurring plant, animal, or mineral sources? (From 7 U.S.C. § 6502 (21).)

Yes, some chemical reactions do occur during the processes by which aquatic plant extracts are obtained from plant sources, such as kelp and seaweed. However, because aquatic plant extracts are complex chemical mixtures, it may not be possible to characterize all the reactions and the extent to which there are chemical changes beyond the simple effects of shifting pH.

Alkali "digestion" of aquatic plants involves the breakdown of galactans in seaweed cell walls (Sideman, 2004). Galactans are tough, fibrous polymeric saccharides (primarily repeating units of galactose). With alkali extraction, this breakdown is accomplished through partial hydrolysis of the galactans, catalyzed by bases (such as sodium hydroxide, potassium hydroxide, potassium carbonate) used in sufficient quantity to achieve a pH of 9 - 10 (Sideman, 2004). Without alkali extraction this breakdown can be accomplished through non-chemical means such as freeze and thaw or grinding.

<u>Evaluation Question #3:</u> Is the petitioned substance created by naturally occurring biological processes? (From 7 U.S.C. § 6502 (21).)

Aquatic plant extracts contain substances that naturally occur in aquatic plants or that are produced when aquatic plants are broken down. As described in Evaluation Question #1, aquatic plant extracts can be produced using nonsynthetic methods. However, aquatic plant extracts produced by alkali digestion, as currently permitted by the National List, are not derived with a naturally occurring biological process.

<u>Evaluation Question #4:</u> Is there environmental contamination during the petitioned substance's manufacture, use, misuse, or disposal? (From 7 U.S.C. § 6518 (m) (3).)

According to Tooby (2003) plant extracts appear to be biodegradable and are likely to have a low impact on crops or stored agricultural products. Additionally, there is no information available from EPA to suggest that environmental contamination results from the manufacture, use, misuse, or disposal of aquatic plant extracts. Environmental contamination could result from improper disposal of acids or bases used in alkali extraction.

<u>Evaluation Question #5:</u> Is the petitioned substance harmful to the environment? (From 7 U.S.C. § 6517 (c) (1) (A) (i) and 7 U.S.C. § 6517 (c) (2) (A) (i).)

No information was uncovered to suggest that aquatic plant extracts could cause toxicity to plants, soil organisms, or higher animals (Original TAP Database Form, 1995).

The potential for over-harvesting of kelp/seaweed fields for production of aquatic plant extracts may be an environmental concern (Chalker-Scott, date unknown; Original TAP Database Form, 1995). However, no evidence has been found indicating that this potential impact is actually occurring.

Additionally, nutrients (i.e., nitrogen, phosphorous, and potassium) found in runoff from excessively or improperly applied fertilizers can cause excess algae growth in surface water (i.e., eutrophication). Excess algae can, in turn, use up oxygen in the water, potentially harming fish and other aquatic animals. No information has been found indicating that aquatic plant extracts are responsible for excessive nutrient runoff.

<u>Evaluation Question #6:</u> Is there potential for the petitioned substance to cause detrimental chemical interaction with other substances used in organic crop or livestock production? (From 7 U.S.C. § 6518 (m) (1).)

Based on the intended use of the substance, no information was uncovered to suggest that aquatic plant extracts could cause detrimental chemical interaction with other substances used in organic crop production.

<u>Evaluation Question #7:</u> Are there adverse biological or chemical interactions in the agro-ecosystem by using the petitioned substance? (From 7 U.S.C. § 6518 (m) (5).)

Some aquatic plant extracts produced by sodium hydroxide extraction may contain excess sodium. If this product is applied at high concentrations, plants may suffer (e.g., foliar damage, decreased plant growth) due to their sensitivity to salt (Original TAP Database Form, 1995).

Aquatic plant extract products that are not neutralized may have a high pH, which has a potential to adversely affect plants. However, no evidence of aquatic plant extract products adversely affecting crops has been identified. No studies have been found comparing the effectiveness of high-pH versus neutralized alkali extracts (Henry, 2005).

<u>Evaluation Question #8:</u> Are there detrimental physiological effects on soil organisms, crops, or livestock by using the petitioned substance? (From 7 U.S.C. § 6518 (m) (5).)

As previously mentioned, aquatic plant extracts can be used as a source of micronutrients and growth promoters and potash[2]; as a rooting solution for transplants and cuttings; for cold hardiness in tomato plant, citrus fruits, and cabbage; and to reduce pest damage (including nematodes in tomato and okra; mites in strawberries, peaches and apples) (Original TAP Database Form, 1995).

Aquatic plant extracts are unlikely to create unacceptable changes in soil temperature, water availability, pH levels, nutrient availability, or salt concentration. However, if aquatic plant extracts produced by sodium hydroxide extraction (which may contain excess sodium) are applied at high concentrations, the plants may suffer from foliar damage (burn) due to their sensitivity to salt (Original TAP Database Form, 1995). Additionally, as previously stated, aquatic plant extract products that are not neutralized may have a high pH, and this has the potential to affect plants adversely. For example, micronutrients (i.e., copper, iron, manganese, zinc, and chloride) tend to be less available in soils with high pH.

<u>Evaluation Question #9:</u> Is there a toxic or other adverse action of the petitioned substance or its breakdown products? (From 7 U.S.C. § 6518 (m) (2).)

Based on their intended use, aquatic plant extracts and their breakdown products are unlikely to have toxic or other adverse actions. Aquatic plant extracts are composed primarily of natural plant constituents, such as proteins, lipids, glucides, amino acids, and vitamins (Original TAP Database Form, 1995). These components are generally biodegradable and nontoxic, and many can be utilized by organisms.

<u>Evaluation Question #10:</u> Is there undesirable persistence or concentration of the petitioned substance or its breakdown products in the environment? (From 7 U.S.C. § 6518 (m) (2).)

According to Tooby (2003), aquatic plant extracts appear to be biodegradable. Thus, the products and their breakdown products are unlikely to have an undesirable persistence in the environment.

[2] Potash refers to a variety of mined and manufactured salts, all containing the element potassium in water-soluble form (USGS, 2001).

Evaluation Question #11: Is there any harmful effect on human health by using the petitioned substance? (From 7 U.S.C. § 6517 (c) (1) (A) (i), 7 U.S.C. § 6517 (c) (2) (A) (i)) and 7 U.S.C. § 6518 (m) (4).)

Other than the potential for lung irritation due to inhalation of the soluble powder form of aquatic plant extract, no adverse effects on human health from the intended use were identified. According to the Material Safety Data Sheet (MSDS) for Necessary Organics' SeaMix Liquid Fertilizer, presented as an attachment to the Original 1995 TAP Database Form, the liquid form poses "no known health hazards" (Original TAP Database Form, 1995). According to Tooby (2003), plant extracts are believed to be associated with likely low adverse effects on human health.

However, the potential for sensitivity or intolerance to seaweed and, therefore, aquatic plant extracts, may exist. For example, it may be possible for some people to be sensitive to monosodium glutamate (MSG)[3], which is found naturally in protein-rich food products, including seaweed. There are some reports that mild, temporary reactions to MSG may occur in a small portion of the population. Nonetheless, MSG is not considered an allergen by the American College of Allergy, Asthma and Immunology (IFIC, 1997). Additionally, the U.S. Food and Drug Administration has found no evidence to suggest any long-term, serious health consequences from consuming MSG (IFIC, 1997).

Evaluation Question #12: Is there a wholly natural product which could be substituted for the petitioned substance? (From 7 U.S.C. § 6517 (c) (1) (A) (ii).)

Natural products that may substitute for aquatic plant extract in its intended use include nonsynthetic fertilizers and soil amendments, including manure, blood meal, bone meal, compost, feather meal, guano, and other nonsynthetic animal or plant products. Also, aquatic plant extracts produced by nonsynthetic means (as described in Evaluation Question #1) are potential substitutes for synthetically produced products.

Although manure is a complete fertilizer, it lacks vital nutrients. An NPK of 1-1-1 is typical for manure[4], though the nutrient content of manure is dependent upon the diet and species of the animal that produced it. Fresh manure contains the highest level of nutrients needed for plant growth.

Evaluation Question #13: Are there other already allowed substances that could be substituted for the petitioned substance? (From 7 U.S.C. § 6518 (m) (6).)

According to the NOP rule (7 CFR 205.601(j)), other allowed plant or soil amendments that could be substitutes for aquatic plant extracts, based on the intended uses, include the following:

- **Humic acids** - naturally occurring deposits, water and alkali extracts only;

- **Micronutrients** - not to be used as a defoliant, herbicide, or desiccant. Those made from nitrates or chlorides are not allowed. Soil deficiency must be documented by testing; and

- **Liquid fish products** - can be pH adjusted with sulfuric, citric or phosphoric acid. The amount of acid used shall not exceed the minimum needed to lower the pH to 3.5; (NOP, 2005).

Evaluation Question #14: Are there alternative practices that would make the use of the petitioned substance unnecessary? (From 7 U.S.C. § 6518 (m) (6).)

Potential alterative practices include recycling compost or other sources of nutrients. Alternative soil building practices include using cover crops, compost and/or manures, reducing tillage, avoiding traffic on wet soils, and maintaining soil cover with plants and/or mulches (Feenstra et al., 1997).

[3] MSG is a sodium salt of the amino acid glutamate (IFIC, 1997).
[4] See: http://www.ext.vt.edu/departments/envirohort/factsheets2/fertilizer/jan89pr6.html

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