

# Triple Superphosphate Crops

## Executive Summary

Triple superphosphate is a synthetic phosphorous fertilizer and appears to be categorically prohibited as such by OFPA [7 USC 6508(b)]. TAP Reviewers were unanimous in their finding that the substance was synthetic, that the petitioned uses are incompatible with organic principles, that alternatives exist, and that the substance should not be added to the National List of Allowed Synthetics.

## Identification

**Chemical Name:** concentrated superphosphate (the term monocalcium phosphate is technically only for food and feed grade)  
**Other Generic Name:** triple (or treble) superphosphate  
**Trade Names:** 0-45-0; 0-46-0; 0-50-0; TSP

**CAS Number:** 65996-95-4 (8011-76-5 is ordinary superphosphate and 7758-23-8 is food and feed grade monocalcium phosphate)  
**Other Codes:** none found

## Summary of TAP Reviewer Analysis <sup>1</sup>

Synthetic / Non-Synthetic:	Allowed or Prohibited:	Suggested Annotation:
<i>Synthetic (3-0)</i>	<i>Prohibited (3-0)</i>	<i>None</i>

## Characterization

**Composition:** Concentrated superphosphate is composed predominately of monocalcium phosphate hydrate (Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub>•H<sub>2</sub>O) and generally contains 43-50% P<sub>2</sub>O<sub>5</sub> (Budavari, 1996). This is distinguished from both ordinary superphosphate and food- or feed-grade monocalcium phosphate such as mono-, di- and tri-basic calcium phosphates. Ordinary superphosphate contains approximately 30% Ca(H<sub>2</sub>PO<sub>4</sub>)<sub>2</sub>•H<sub>2</sub>O with the remaining composed of approximately: 45% gypsum by-product; 10% calcium biphosphate (CaHPO<sub>4</sub>); 10% iron oxide, silica, and aluminum; and 5% water (Budavari, 1996).

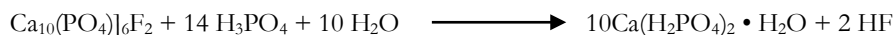
**Properties:** Large, shining triclinic plates; crystalline powder; or granules (Budavari, 1996).

**How Made:** Superphosphates can be either ordinary or triple, depending on the phosphate (P<sub>2</sub>O<sub>5</sub>) content. Ordinary superphosphate is produced by the reaction of a rock phosphate with sulfuric acid (H<sub>2</sub>SO<sub>4</sub>). This can be theoretically characterized as (Tisdale and Nelson, 1966):



yielding a product that contains between 18-20% P<sub>2</sub>O<sub>5</sub> (Maynard and Hochmuth, 1997).

The petition addresses triple superphosphate specifically by CAS #65996-95-4. The production of triple superphosphate from raw apatite ore involves a complex series of reactions. These all involve phosphoric acid, and may or may not also use sulfuric acid. Monocalcium phosphate is only one of the products of the process. Theoretically, triple superphosphate is made by the reaction of fluorapatite with phosphoric acid in aqueous solution (Hoffmeister, 1993):



<sup>1</sup> 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 (OFPA) to the best of the investigator'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 advice presented to the NOSB is based on the technical evaluation against that criteria, and does not incorporate commercial availability, socio-economic impact or other factors that the NOSB and the USDA may want to consider in making decisions.

52  
53 This is a simplification of the actual manufacturing process (Follett, Murphy, and Donahue, 1981). Actual production  
54 methods vary, and usually involve a number of different reaction steps (Górecki, 1994). One of the most widely used  
55 manufacturing processes is the Dorr-Oliver process (Hoffmeister, 1993; Górecki, 1994) also known as the granular TSP  
56 method (US EPA 1999b), with another method developed by the US Department of Agriculture and the Tennessee Valley  
57 Authority (TVA) accounting for much historical production (Philips and Webb, 1971). This other method is known in the  
58 industry as run-of-the-pile (ROP-TSP) (US EPA 1999b). Both of these methods are “wet process phosphoric acid” such  
59 as the petition describes. The basic chemical reactions are the same, with the main differences being in the physical  
60 handling and processing. Another process involves the reaction of limestone with phosphoric acid (Bierman and Long,  
61 1978).

62  
63 Sources of tricalcium phosphate, one of the ingredients in the superphosphates, include mined rock phosphate such as  
64 apatite ores (fluorapatite and oxyapatite), voelcherite, and whitlockite. Tricalcium phosphate can also be recovered from  
65 bones and bone meal; the petition specifically lists “monocalcium phosphate, a salt derived from rock phosphate.”  
66

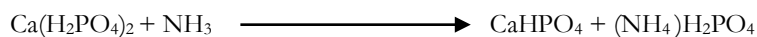
67 Some references used for this review refer to “superphosphate” in the singular form and do not distinguish between  
68 ordinary and triple. These are listed in this document as superphosphate. When the superphosphates (plural) is used, this  
69 refers to both ordinary and triple forms.  
70

71 While fertilizer grade triple superphosphate is made from direct acidulation of rock phosphate, the impurity levels are  
72 generally too high for other applications. Monocalcium phosphate used for baking powder (CAS # 7758-23-8, different  
73 than this petitioned material for crops use) is crystallized from a reaction mixture of concentrated phosphoric acid and  
74 lime, or by spray-drying a slurry of the product of a reaction of lime and phosphoric acid (Petersen and Freilich, 1992).  
75

76 **Specific Uses:** The chief uses of superphosphates include as phosphate fertilizers, for enameling, and in construction  
77 material. Food and feed grade monocalcium phosphate (CAS # 7758-23-8) is used as an acidulant in baking powders and  
78 as a mineral supplement for various foods and livestock feed.  
79

80 **Action:** Superphosphates are applied to soil and used in fertilizer as a source of plant available phosphate (Baker, 1925;  
81 Karrabaker et al., 1941; Collings, 1950; Tisdale and Nelson, 1966).  
82

83 Specific to the petition, the monocalcium phosphate in the triple superphosphate reacts with the ammonia in manure by  
84 the following reaction (from Midgley and Weiser, 1937):  
85



88 Superphosphates are also acidifying, and may be used to lower the pH of soils and transplant media (Parnes, 1990).  
89 Phosphorus precipitates in the form of various calcium phosphate compounds at higher pHs (Bohn, et al., 1979; 1985).  
90

91 **Combinations:** Monocalcium phosphate is the primary component of both ordinary and triple superphosphate. Ordinary  
92 superphosphate contains a certain amount of by-product gypsum from the reaction. Commercial ordinary and triple  
93 superphosphate can be blended with a wide range of materials, including compost (Rynk, et al., 1992). Many  
94 superphosphates are enriched with ammonia (Tisdale and Nelson, 1966). (Point of clarification from the investigator:  
95 After considering information provided by the petitioner and the reviewers, it appears that many of the empirical studies  
96 cited here that document superphosphate’s ability to stabilize ammonia were conducted on manure rather than on  
97 compost. In compiling the TAP review, where possible we sought to make clear the medium that was receiving either the  
98 superphosphate treatment or one of the alternatives.)  
99

## 100 **Status**

101 **Historic Use by Organic Growers:** The use in organic farming systems has long been discussed (Parnes, 1990).  
102 However, superphosphates are generally not used by certified organic farmers. See below under “Status Among U.S.  
103 Certifiers” for some historical exceptions.  
104

### 105 **OFPA, USDA Final Rule:**

106 Prohibited as a synthetic phosphate fertilizer under OFPA, 7 USC 6508(b)(1). The petition is to use triple superphosphate  
107 as an ingredient to make compost [see Final Rule 7 CFR 205.105(a), 205.203(e)(1), and 205.601(c)].  
108

109 As the petition notes, the NOP Final Rule allows phosphoric acid to be used for certain specific uses and applications.  
110 Phosphoric acid is allowed to be used to adjust the pH in liquid fish fertilizers provided the amount of acid used does not

111 exceed the minimum to lower the pH to 3.5 [205.601(j)(7)]. Phosphoric acid is also allowed to clean equipment cleaner  
112 used in livestock production and in processing [205.603(a)(13) and 205.605(b)(22)]. No other uses are listed.

113  
114 Food grade mono-, di-, and tri-basic calcium phosphate appear on the National List for use as a minor ingredient in dairy  
115 products [7 CFR 205.605(b)(7)]. Also, FDA approved feed grade calcium phosphates may be permitted as feed additives  
116 used for enrichment or fortification [7 CFR 205.603(d)(1)]. As discussed above, food and feed grade calcium phosphates  
117 are not identical to fertilizer grade superphosphates.

#### 118 **Regulatory: EPA/NIEHS/Other Sources**

119 EPA – The EPA does not regulate monocalcium phosphate, ordinary superphosphate or triple superphosphate as a  
120 hazardous substance. Phosphoric acid was removed from EPA's Toxic Release Inventory (TRI) list in 1999 based on a  
121 ruling by the US District Court for the District of Columbia (Jasinski, 1999). EPA limits radon emissions from  
122 phosphogypsum (fertilizer phosphorous and by-product gypsum) stacks (US EPA 1999a). Hydrogen fluoride emissions  
123 from phosphoric acid and phosphate fertilizer factories are also regulated by EPA (US EPA 1999a).

124  
125 NIEHS – The National Toxicology Program (NTP) does not have a monograph on monocalcium phosphate or any form  
126 of superphosphate.

127  
128 Other Sources – The Association of American Plant Food Control Officials' (AAPFCO) various state officials regulate  
129 superphosphates as plant foods. Superphosphate is obtained when rock phosphate is treated with either sulfuric acid or  
130 phosphoric acid, or with a mixture of those two acids (AAPFCO, 2000).

#### 131 **Status Among U.S. Certifiers**

132  
133 Prohibited by all U.S. certifiers except Maine Organic Farmers and Gardeners Association (MOFGA). MOFGA has  
134 historically allowed it for use as a compost ingredient only for use in potting media. MOFGA prohibits field application of  
135 such compost. The MOFGA standards list as permitted, “ B.5.: transplants raised in a so-called ‘organic’ potting mix  
136 containing compost that has superphosphate or iron sulfate added to stabilize nitrogen during composting process.” The  
137 standards then state “Potting mixes made with compost described above in B.5. will not be permitted after the 2001  
138 growing season” (MOFGA, 2001).

139  
140 The petition states an allowance for the petitioner's compost and greenhouse mix, “...New Hampshire NOFA, where a  
141 state-run review continued to allow both” (Ramsey, 2000). The New Hampshire Department of Agriculture lists  
142 superphosphate as prohibited [NH Agricultural Administrative Rule 906.04(c)(5)(f)]. This extends to both ordinary  
143 (normal) superphosphate and triple superphosphate, both field applied and as a compost feedstock (Uncles, 2001).  
144 NOFA-New Hampshire is a grower group and does not conduct an organic farm certification program.

#### 145 **International**

146  
147 CODEX – Prohibited since not explicitly listed as allowed.

148  
149 EU 2092/91 – Prohibited since not explicitly listed as allowed.

150  
151 IFOAM – Prohibited since not explicitly listed as allowed.

152  
153 Canada – Prohibited since not explicitly listed as allowed.

154  
155 Japan – Prohibited since not explicitly listed as allowed (from the unofficial English translation).

156  
157 Other International Certifiers – None known of outside the US that allow superphosphates in crop production.

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

159  
160 1. *The potential of the substance for detrimental chemical interactions with other materials used in organic farming systems.*

161 In general, most of the literature considers the interaction between compost and superphosphate to be beneficial  
162 rather than detrimental, in that organic matter maintains superphosphate in solution. One composting guide states  
163 that superphosphate conserves nitrogen in dairy manure during composting (Rynk, et al., 1992). This conserves  
164 ammonia nitrogen in the compost, stimulates phosphate uptake, and provides a production response. This includes  
165 composts used in potting soil (Bunt, 1976). [Note that in this and other references, particularly those that use British  
166 English, the word ‘compost’ is sometimes used to refer to generic potting soil that does not necessarily include  
167 compost as defined by the NOP Final Rule.]

170 Combinations with many nitrate-based fertilizers can be highly volatile. The most serious potential detrimental  
171 interaction is with sodium (Chilean) nitrate in wet conditions. Early efforts to produce a balanced fertilizer by mixing  
172 sodium nitrate and superphosphates resulted in an unstable mixture (Collings, 1950).  
173

174 Potentially a much more common detrimental interaction would be nutrient tie-up from incompatible blending or  
175 excessive application. While soluble, superphosphate rapidly becomes fixed to soil particles (Baker, 1925). The  
176 primary interactions in the soil are free  $\text{H}_2\text{PO}_4^-$ ,  $\text{HPO}_4^{2-}$  and  $\text{PO}_4^{3-}$  anions with available cations. The reactions are  
177 based on available cations and soil pH, with the following preference in binding to cations observed as pH rises: iron  
178 > aluminum > calcium = magnesium > sodium (Follett, Murphy, and Donahue, 1981). Thus, depending on pH and  
179 other conditions, limestone, dolomite, and iron could be tied up from a phosphate excess or incompatible mixing.  
180 Other essential micronutrients may also be tied up by phosphorous. For example, a heavy application of phosphate  
181 could induce a zinc deficiency (Ludwick, et al., 1990).  
182

183 The enhanced solubility of superphosphates can be considered detrimental. Superphosphates become more mobile  
184 with management techniques common to organic production. Despite being fixed in most situations, over a longer  
185 time period, superphosphates will leach to a certain extent. Factors that increase the rate of leaching are related to soil  
186 management. The rate at which phosphate is fixed or conversely how much it will leach depends most on available  
187 iron, aluminum, magnesium, soil organic matter, and the activity of soil microorganisms (Brady, 1974). One  
188 experiment showed fields that received farmyard manure and superphosphate had twice as much soluble phosphate  
189 in the subsoils as fields that received farmyard manure alone (Warren and Johnston, 1961, cited in Cooke and  
190 Williams, 1973). It is not clear if this was because organic matter maintained superphosphate in solution longer or  
191 simply because the phosphate levels were higher in the superphosphate treated fields.  
192

193 Also, in organic compost based potting mixes, ammoniacal nitrogen ( $\text{NH}_4\text{-N}$ ) is high relative to nitrate nitrogen  
194 ( $\text{NO}_3\text{-N}$ ) (Brinton and Tresemer, 1988). By maintaining nitrogen in ammoniacal form, the addition of triple  
195 superphosphate may exacerbate this imbalance. As noted below (5) superphosphates can depress the levels of  
196 vesicular-arbuscular mycorrhizae (VAM). Various inoculants used contain VAM. One TAP reviewer found an article  
197 and an unpublished paper that supported the benefits of phosphate fertilization to earthworms, but the studies did  
198 not describe the sources of phosphorous or the research methods adequately.  
199

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

202 Monocalcium phosphate itself is considered generally non-toxic (Ramsey, 2000). Fertilizer-grade triple  
203 superphosphate will form free acids and can release fluorides (IMC, 1988). The mobility and fixity of soluble  
204 phosphate is a long-studied subject. Persistence of phosphate is generally not considered a problem, except when  
205 excessive amounts tie up other nutrients. As noted above, soluble phosphate has long been considered fixed to soil  
206 particles after a relatively short period of time. Superphosphates will generally adsorb to clay and react with cations in  
207 the soil depending on pH, cation exchange capacity, and available cations. Leaching of soluble, or runoff of,  
208 phosphate fertilizer bound to eroding soil is a source of phosphate in rivers, lakes, and streams, although the amount  
209 and significance of the contribution of fertilizer sources is questionable (Cooke and Williams, 1973). Empirical  
210 evidence supports that soluble fertilizer runoff and excessive phosphate fertilization contributes to overall water  
211 pollution caused by erosive and intensive soil management practices (National Research Council, 1989).  
212

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

214 The superphosphates manufacturing processes generate air pollution (US EPA, 1999b), an effluent stream (Górecki,  
215 1994), solid waste that can contain high levels of toxic heavy metals (EPA, 1999a), and radioactive waste (Bunus,  
216 1994; EPA, 1994) that can potentially include hazardous components (EPA, 1999a). Acidulation of apatite produces  
217 hydrofluoric acid (HF), a very strong acid that is highly reactive (Górecki, 1994). Liquid or vapor HF causes severe  
218 irritation of the eyes and eyelids and may result in prolonged or permanent visual defects or total destruction of the  
219 eyes. Skin contact may result in painful burns. Inhalation of HF results in extreme irritation of the respiratory tract,  
220 pulmonary inflammation, and congestion. HF ingestion results in necrosis of the esophagus and stomach with nausea,  
221 diarrhea, vomiting, circulatory collapse, and death (Budavari, 1996). The technology to remove and recover fluoride  
222 from the HF in both single and triple superphosphate manufacturing has made great strides since the 1950s but has  
223 not been installed in all manufacturing plants and still can be improved (Górecki, 1994).  
224

225 Phosphate fertilizers are known to contain varying levels of heavy metals such as cadmium, lead, nickel, and  
226 chromium (Charter et al., 1993; Mortvedt, 1987). These metals may originate in the phosphate rock (Mortvedt and  
227 Giordano, 1977). The cadmium and other metals remain with the phosphate during processing (Wakefield, 1980,  
228 cited in Center for Environmental Analysis, 1999). Other contaminants produced from the manufacturing process  
229 include arsenic, cadmium, and lead. All of these heavy metals are naturally occurring in the ore.

230  
231 Certain sources of rock phosphate, and the phosphoric acid and triple superphosphate from which they are derived,  
232 are also radioactive from contamination with uranium as  $^{238}\text{U}$ , thorium as  $^{232}\text{Th}$ , and radon as  $^{226}\text{Rn}$  (Bunus, 1994).  
233 Some forms of processing can remove the radioactive isotopes; other processing methods will concentrate the  
234 isotopes in the fertilizer (Bunus, 1994).  
235  
236 4. *The effects of the substance on human health.*  
237 Calcium and phosphate are both essential nutrients important for bone formation, metabolic function, and other  
238 biological processes. The active calcium phosphate is not considered a human health risk. However, elemental  
239 contamination of triple superphosphate with arsenic, cadmium, fluorine, and lead may be potential risks to human  
240 health (US EPA, 1999b). The presence of radionuclides in superphosphates may also pose a human health risk (US  
241 EPA, 1999).  
242  
243 5. *The effects of the substance on biological and chemical interactions in the agroecosystem, including the physiological effects of the substance on*  
244 *soil organisms (including the salt index and solubility of the soil), crops and livestock.*  
245 The water solubility of phosphate fertilizers is highly variable (Phillips and Webb, 1971). Superphosphates are more  
246 soluble than tricalcium phosphate from either rock phosphate or bone meal. The concentrated solution that moves  
247 from triple superphosphate is very acid—the pH is approximately 1.5—and dissolves Fe, Al, Mn, and Ca from the  
248 soil to form precipitates of varying solubility (Phillips and Webb, 1971). Solubility is also influenced by the other  
249 ingredients and the particle size. Smaller particles are more soluble; larger particles are less soluble.  
250  
251 The salt index is 10.1 (Rader, Whittaker, and White, 1943; Meister, 2001). Solubility of triple superphosphate is 1.8 at  
252 30°C (Meister, 2001). Superphosphate used in transplant media has been shown to leach from the containers at a rate  
253 proportional to the amount used (Nelson, 1990); particle size, air space (Yeager and Barrett, 1984); and time the  
254 plants are in pots (Yeager and Barrett, 1985). None of the studies cited used compost as described in the petition.  
255  
256 Vesicular-arbuscular mycorrhizae (VAM) are symbiotic with plants and help to cycle relatively insoluble nutrients,  
257 including phosphate. VAM have been shown to increase the availability of relatively insoluble nutrients in the soil, in  
258 particular phosphorous, copper, and zinc. Superphosphate fertilizer has been shown to suppress VAM (Amijee, et al,  
259 1989; Vivekanandan and Fixen, 1991) and decrease the length of root that is colonized (Thomson, et al., 1992). VAM  
260 suppression has been documented at relatively low rates of application of P-fertilizer (Clapperton, Janzen, and  
261 Johnston, 1997).  
262  
263 6. *The alternatives to using the substance in terms of practices or other available materials.*  
264 The petition states that for adjusting pH in compost, “The only other material which could be used and is currently  
265 on the National List for crop production, is iron sulfate.” Iron sulfate does not appear under compost feedstocks  
266 [205.601(c)]. Iron sulfate can be considered a micronutrient on the National List of allowed substances  
267 [205.601(6)(ii)]. The annotation requires that to apply the substance, the operator must document a soil deficiency by  
268 testing.  
269  
270 The investigator and reviewers discovered a number of materials and management practices that have historically and  
271 are currently used as alternatives to triple superphosphate for this purpose. These include: lowering or the pH by the  
272 use of natural substances; addition of carbon; efficient compost pile management; and the timing of compost or  
273 manure application. Various non-synthetic substances can be used to buffer or lower the pH of compost.. Sources  
274 allowed under the NOP Final Rule include bone meal, animal manures with a relatively high phosphorous content  
275 (e.g., poultry manure) (Parnes, 1990), compost, and rock phosphate (Lampkin, 1990; Parnes, 1990). In general,  
276 commonly mixed organic materials will usually create a balanced pH in the optimum range of 6.5-8.0 in a properly  
277 made compost (Rynk, et al., 1992).  
278  
279 Considerable research has been done on conservation of ammonia in manure, with most experiments conducted in  
280 the first half of the 20<sup>th</sup> century. Most of these studies did not involve compost made according to NOP Final Rule  
281 standards. Highly alkali compost—for example where horse manure is a feedstock—can be buffered by the addition  
282 of gypsum or peat, but the ammonia preservation and reduction of volatilization appears relatively poor when  
283 compared with superphosphates (Collison and Conn, 1922). The addition of rock phosphate and various clays will  
284 help to reduce ammonia volatilization during the composting process (van Horn, 1995).  
285  
286 Management techniques can make a significant difference in controlling ammonia losses. Proper composting can  
287 stabilize and conserve ammoniacal nitrogen ( $\text{NH}_4\text{-N}$ ) (Sheppard, Phillips, and Bhogal, 2000). In-vessel composting  
288 and less frequent turning of aerobic compost can conserve ammonia (van Horn, 1995). Timing, waiting for warmer  
289 soil temperatures, and rapid incorporation into the soil can also reduce ammonia losses (Heck, 1931). Water

290 management and recycling leachate can conserve nitrogen during the composting process (van Horn, 1995). Liquid  
291 manure experiences greater ammonia loss than a manure that is bulked or dried (Heck, 1931).

292  
293 High ammonia losses are generally correlated with a carbon:nitrogen (C:N) ratio that is sub-optimal. Ammonia can be  
294 conserved through the addition of carbon to raise the C:N ratio (Rynk, et al., 1992). Carbon sources that produce  
295 organic acids, including humic acid can also lower pH and conserve ammonia. Fruit pomaces, sawdust, and other  
296 plant-derived feedstocks can help to balance the pH of a well-prepared compost. An earlier bulletin from the  
297 University of Massachusetts experiment station supports the efficacy of superphosphate but does not consider rock  
298 phosphates (Lindsay, 1912). Elemental sulfur can also lower pH (Tisdale et al., 1985). Sulfur appears on the National  
299 List of allowed synthetic substances for fertilization [205.601(j)(2)], but not as a compost feedstock [205.601(c)]. Non-  
300 synthetic sources of sulfur exist, although the last sulfur mine in the US closed in 1999 (Ober, 1999).

301  
302 Ammonia nitrogen can be conserved by increasing the C:N ratio. The addition of straw is useful in ammonia  
303 conservation when gathering and storing raw manure (Yusok and Bear, 1943). The increased carbon increases  
304 microbial growth which consumes nitrogen at the same time (Brady, 1974). Ammonia loss is highly correlated with  
305 pH. Free ammonia increases from 1% to 10% as pH increases from 7 to 8 (Tisdale et al., 1985). The  
306 carbon:phosphorus (C:P) ratio can significantly influence biological degradation where the C:N ratio is 30:1 or greater.  
307 Some municipal solid waste (MSW) compost is composed primarily of paper and has very low nitrogen and  
308 phosphorus contents. In this context the C:N and C:P of MSW with an initial C:N ration of 53:1 was modified with  
309 TSP and ammonium nitrate to achieve C:N from 53:1 to 30 :1 and C:P ratios of 500:1 to 60:1. The treatments were  
310 composted for four weeks. Increasing the C:P ratio increased soluble N in this high carbon environment (Brown et  
311 al., 1998). This composting environment is different from composting manure or another feedstock with a high N  
312 content. One study compared ammonia emissions from food waste, yard waste, and MSW composting and found  
313 that the greater the initial nitrogen content of the feedstock, the greater the ammonia loss by volatilization during  
314 composting. The researchers did not add or evaluate the effects of phosphorus because they said phosphorus is not  
315 usually added during composting operations (Komilis and Ham, 2000).

316  
317 Phosphorus chemistry is complex, and it is difficult to predict with accuracy the correspondence between soil  
318 phosphorous concentrations and solubility, and plant phosphorous status for plants (Bohn et al., 1985). Rock  
319 phosphate, bone meal, and compost from phosphate-rich sources can all provide adequate phosphorous in potting  
320 soils. There appear to be considerably more alternatives to compost with superphosphates for field use outside of use  
321 in potting media. At high pH, the mined minerals variscite and strengite are soluble and should make good fertilizers  
322 if finely ground (Bohn et al., 1985). These would be phosphorus sources that could be substituted for triple  
323 superphosphate.

324  
325 In addition to all the alternatives listed above, mulches and green manures (Lampkin, 1990) are used for both  
326 phosphate cycling and nitrogen conservation. Rotating legumes can enhance rock phosphate mobilization in alkaline  
327 soils where P would otherwise be relatively unavailable (Aguilar and van Diest, 1981). Composting low-grade rock  
328 phosphate [allowed in the Final Rule at 205.203(d)(2)] can enhance P availability to be comparable to applications of  
329 single superphosphate (Singh and Amberger, 1995). VAM makes relatively insoluble phosphorous more available  
330 (Virant-Klun and Gogala, 1995).

331  
332 7. *Its compatibility with a system of sustainable agriculture.*

333 Acidified phosphorous fertilizer in general, and triple superphosphate in particular, is one of the specific items used in  
334 the discussion of the sustainability of organic farming systems. One of the defining characteristics long-used to  
335 identify organic farms is the production of crops without acidified phosphorous fertilizer such as superphosphate or  
336 triple superphosphate (Lockeretz, Shearer, and Kohl, 1981). Approaches that use relatively insoluble sources of P and  
337 enhanced activity of P-solubilizing bacteria may provide a more biorational and sustainable approach to P fertilization  
338 than the use of acidulated P-fertilizers such as superphosphates (Goldstein, 1986).

339  
340 Farmers who engage in practices that are largely sustainable and long-time proponents of organic farming have  
341 questioned the sustainability of prohibiting chemically refined phosphorous fertilizer (for example, Logsdon, 1993).  
342 Many of the practices that are cited as reasons why triple superphosphate is not sustainable can be applied to the  
343 alternatives as well (Parnes, 1990). None of the sources who see triple superphosphate as sustainable state so without  
344 qualification, including in the petition as a soil amendment. Research and crop management guides for sustainable soil  
345 management generally recognize that most soluble sources of phosphate are usually applied in excess and most does  
346 not go to the plant. The USDA (1980) estimated that most farmers could eliminate phosphate applications and not  
347 suffer yield reductions, at least in the short run. Even when not eliminated, phosphate applications can be better used  
348 through reduced and split applications, increased testing, and soil conservation practices (Cramer, 1986; National  
349 Academy of Sciences, 1988).

350  
351 Because it is produced by a synthetic manufacturing process from non-renewable resources and has relatively high  
352 solubility compared with the alternatives, triple superphosphate is generally not considered compatible with a system  
353 of sustainable agriculture.  
354

## 355 **TAP Reviewer Discussion<sup>2</sup>**

### 356 **Reviewer 1**

357 *[Midwest--provides technical services to growers, extensive experience in organic and sustainable agriculture]*

358 Reviewer 1 submitted substantial comments and corrections to the text of the review (and these are incorporated in),  
359 voted that the material is synthetic and should not be added to the National List, and did not have any additional  
360 points for discussion.  
361

### 362 **Reviewer 2**

363 *[West--researcher and consultant for organic growers, certification experience]*

364 There are adequate organically acceptable materials and practices to the use of this material for composting. The  
365 effect on pH of the compost materials from the addition of the triple super phosphate appears to be nominal, from  
366 the applicant's own information. Thus its need to be used for pH adjustment seems inconsistent with the applicants  
367 own experience. Additionally, there are organically acceptable alternatives that will significantly address the ammonia  
368 volatilization issues. The material is inconsistent with the long held practice of stimulating soil biological activity to  
369 provide fertility for crops. The material is prohibited by virtually all national and international organic certifiers.  
370 Increasing the solubility of phosphorus can lead to the reduction of mycorrhizae, which are essential to healthy  
371 organic plants.  
372

### 373 **Reviewer 3**

374 *[East--doctorate in plant pathology, M.S. soil science, expertise in compost management]*

375 [H]igh nitrogen compost feedstocks are blended with high carbon feedstocks to optimize the composting process and  
376 reduce ammonia loss. Ammonia volatilization during manure composting is recognized as a problem. Researchers  
377 have shown that ammonia volatilization can be reduced during manure composting by adding MSW to increase the  
378 carbon content of the feedstock (Sikora, 1999). If the petitioners wish to reduce ammonia volatilization, increasing  
379 the carbon content of their compost feedstock would be an effective method.  
380

381 The petitioners also indicate that TSP is beneficial to their composting process. This reviewer has not found articles  
382 evaluating the impact or interaction of TSP in the composting process. There is a body of literature that evaluates  
383 leaching of phosphorus under various conditions. Siddique et al. (2000) found that soils fertilized with monocalcium  
384 phosphate leached P more than did soils amended with anaerobically treated sewage sludge. Although these sludges  
385 were treated with a biological anaerobic process, it is not clear from the article if chemical flocculants were added to  
386 the sludge during the dewatering process. Chemical flocculants can greatly affect nutrient retention properties of  
387 sludge. The authors found that as much as 80% of the P in the sludge was in an inorganic, unavailable form.  
388 Sharpley and Sisak (1997) found that P availability was greater in soils fertilized with  $\text{KH}_2\text{PO}_4$  than with uncomposted  
389 poultry litter. Because of the complexity of phosphorus chemistry and the variables involved in composting versus  
390 raw manure or sludge application this reviewer can not evaluate the changes to TSP and its availability during and  
391 after the composting process without further information.  
392

393 In general the applicant has options available to them to provide a phosphorus source, reduce ammonia loss, and  
394 reduce pH other than using TSP. For this and reasons discussed above this reviewer feels TSP should not be added  
395 to the national list.  
396

397 This reviewer wishes to raise an issue that is beyond the scope of this current review but should be evaluated by the  
398 organic community at some point. This is the need for a comparison and consideration of the efficiency of rock  
399 phosphate versus triple super phosphate (TSP) in light of the extensive environmental damage caused by the mining  
400 of rock phosphate. The evaluation should include which product, rock phosphate or TSP causes the greatest overall  
401 environmental damage in terms of volume of land that is mined to meet agricultural production, processing, soil and  
402 water quality impacts. This is a complicated issue because it involves mining, processing and use impacts. Again it is  
403 clearly beyond the scope of this review but deserves consideration at some point.

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<sup>2</sup> OMRI's information is enclosed in square brackets in italics. Where a reviewer corrected a technical point (e.g., the word should be "intravenous" rather than "subcutaneous"), these corrections were made in this document and are not listed here in the Reviewer Comments. The rest of the TAP Reviewer's comments are edited for any identifying comments, redundant statements, and typographical errors. Additions to the TAP review text were incorporated into the review. Text removed is identified by ellipses [...]. Statements expressed by reviewers are their own and do not reflect the opinions of any other individual or organizations.

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