

# Environmental Chemistry of Phosphonates

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**Abstract-** Phosphonates contain one or more C-PO(OH)<sub>2</sub> groups and function as human complexing agents. Chelating agents and scale inhibitors are two of their many industrial and technical uses. Phosphonates are distinguished from other chelating agents by characteristics that have a significant impact on their behavior in the environment. Phosphonates have a significant removal in both natural and technological systems due to their strong interaction with surfaces. Because of this solid adsorption, practically zero remobilization of metals is normal. Phosphate is not broken down by biodegradation during water treatment, but the Fe(III)-complexes are broken down quickly by photo degradation. In the presence of Mn(II), aminopolyphosphonates also undergo rapid oxidation, resulting in the formation of oxygen and stable breakdown products that have been observed in wastewater. Analytical difficulties in determining phosphonates at trace concentrations in natural waters are to blame for the lack of environmental information. In this area, further method development, including speciation of these compounds, is urgently required. Based on the current understanding of speciation, we can conclude that phosphonates have no effect on metal speciation or transport because they are mostly Ca and Mg-complexes in natural waters.

**Keywords-** Phosphonates; Chelating agents; Adsorption; Heavy metals; Degradation; Speciation.

## I. INTRODUCTION

Compounds with the Lewis acid moiety R-CP(O)(OH)<sub>2</sub> are known as phosphonic acids because of their stable covalent carbon-phosphorous bond. Phosphate anions of phosphonic acids are referred to as phosphonates. The most generally utilized phosphonates are primary analogs to the notable aminopolycarboxylates, for example, ethylenediaminetetra acetic acid derivation (EDTA) and nitrilotriacetate (NTA). The natural destiny of these aminopolycarboxylate chelating specialists has gotten significant consideration [1-5]. Considerably less is had some significant awareness of the destiny and behavior of the relating phosphonates in the climate [4,6,7]. The current audits are either quite a long while old and hence don't cover the freshest writing [6] or center around toxicology and

hazard evaluation in light of the restricted information that were accessible around then [7]. An overview of these compounds' chemistry is missing, which would allow us to better comprehend and predict their environmental behavior, which would serve as the foundation for a refined risk assessment. Therefore, the purpose of this review is to provide an overview of the current understanding of phosphonate environmental chemistry. It focuses on aminopolyphosphonates, which are compounds with multiple phosphonate and one or more amine groups, and polyphosphonates, which are compounds with multiple phosphonic acid groups, in particular.

Glyphosate, a herbicide containing a phosphonate, a carboxylate and an amine useful gathering, isn't examined exhaustively in this survey. However, there is a lot of information about this compound's

environmental chemistry and behavior [8–10]. A brief overview of the properties and analysis of phosphonates serves as the basis for this review. The following surface reactions are covered in the section on phosphonates' interactions with surfaces: adsorption, mineral dissolution, metal remobilization, phosphonate precipitation, and inhibition of mineral precipitation. In the debasement segment biodegradation, photodegradation, synthetic corruption and corruption during oxidation processes are examined. The speciation of phosphonates in the climate covers the following segment, which is trailed by a conversation of their natural way of behaving. This part contains a synopsis of the information on estimated groupings of phosphonates and their way of behaving during wastewater treatment.

## II. PROPERTIES

The compounds are known by many different names, some of which have changed over time and apply to different fields and countries. According to the IUPAC definition, chelation is the coordination of more than one sigma-electron pair donor group from the same ligand to the same central atom. Phosphonates are effective chelating agents. Phosphonates are utilized as chelating agents in a variety of contexts, including the pulp, paper, and textile industries, where they are used to remove complex heavy metals from chlorine-free bleaching solutions that may inactivate peroxide. For the treatment of bone cancer, phosphonates are used in medicine to chelate radionuclides [11]. The available experimental data on the stability constants of proton and metal complexes for phosphonic acids are critically analyzed in a recent IUPAC Technical Report [12]. It presents excellent information as "recom-retouched" or "temporary" constants while for instance, all constants for DTPMP have been dismissed because of inadequate virtue of the parent compound. This report will be of incredible use for all future speciation computations and ought to be the sole wellspring of dependability constants whenever the situation allows.

The stability of the metal complexes increases with increasing number of phosphonic acid groups.

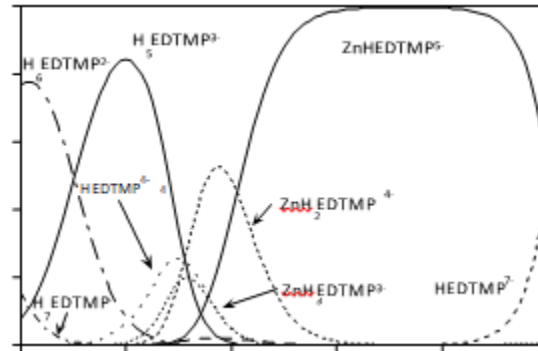


Fig. 1: shows that the monophosphonate aminomethylphosphonic acid (AMPA) has the lowest stability constants

Fig 1. Stability constants of 1:1 complexes (M+HL) with transition metals of AMPA, IDMP, HEDP, NTMP and EDTMP (Irving–Williams series) with data for EDTMP with 4 phosphonic acid groups the highest. The log K values of the different transition metal complexes follow the Irving–Williams series  $Mn^{2+} < Fe^{2+} < Co^{2+} < Ni^{2+} < Cu^{2+} > Zn^{2+}$  Fig shows a speciation diagram for the system Zn- EDTMP calculated with the constants from [12] with the speciation program ChemEQL [13].

This calculation demonstrates that there are numerous potential complexes with varying degrees of protonation and charge in the pH range found in natural waters and technical applications. At pH 6 the species  $H_4EDTMP^{4-}$ ,  $ZnH_3EDTMP^{3-}$ ,  $ZnH_2EDTMP^{4-}$  and  $ZnHEDTMP^{5-}$  happen at a level of over 5% of all out EDTMP. Similar complexation of other metals by other phosphonates occurs, and multiple species coexist at each pH value. Phosphonates are not only chelating agents but also extremely potent growth and precipitation inhibitors of minerals. At concentrations significantly lower than those required to chelate all metals, this effect is effective. Phosphate precipitation, such as barium sulfate or calcium carbonate precipitation, is a significant industrial use of phosphonates in oil fields, desalination systems, and cooling waters to prevent scale formation. Phosphonates are also used in medicine to treat a variety of diseases related to the

metabolism of calcium and bone [14]. In cleansers phosphonates are utilized as a blend of chelating specialist, scale inhibitor and dye stabilizer [15]. While phosphonic acids are only sparingly soluble in water, phosphonates are highly soluble in water. Phosphonates are inorganically insoluble and non-volatile. More detailed data on the physico-chemical properties of the phosphonates can be found in reference [7]. In 1998, 56,000 tons of phosphonates were consumed worldwide, while 16,000 tons were consumed in Europe in 1999 [4]. Europe and the United States have data on the distribution of the various phosphonates [6, 7], the Netherlands [8, 9], and Germany [4, 10]. Based on the volumes used, the phosphonates HEDP and DTPMP are the most important. Phosphate is not very harmful to aquatic organisms. Revealed values for 48 h LC50 values for fish are somewhere in the range of 0.1 and 1.1 mM. Additionally, fish's bioconcentration factor is extremely low. Phosphonates are ineffectively caught up in the gastro-digestive system and a large portion of the retained portion was quickly discharged by the kidneys. Human poisonousness is likewise low which should be visible in the way that phosphonates are utilized to treat different sicknesses.

### III. ANALYSIS OF PHOSPHONATES

#### 1. Analytical Methods

The shortfall of a solid follow scientific strategy for phosphonates brings about an absence of itemized data about the natural way of behaving of phosphonates. The majority of current methods for phosphonate detection either have detection limits that are higher than what would be expected from natural samples or are affected by interferences. The standard technique for the assurance of phosphonates is particle chromatography followed by post-segment response with Fe(III) and identification of the Fe(III)- edifices at 300-330 nm. This technique has a location cutoff of around 2-10 mM. Based on the post-column oxidation of the phosphonate to phosphate and the molybdenum blue method's detection of phosphate, other methods have been developed. Capillary electrophoresis with indirect photometric detection,

ion chromatography with pulsed amperometric detection of amine-containing phosphonates, and ion chromatography with indirect photometric detection are also described. Since each of these methods has high detection limits of at least 1 mM, they are not suitable for natural systems. Derivatization of the phosphonic acid group with diazomethane, followed by separation and detection of the derivatives using HPLC-MS, is a very effective strategy. Due to interference from the major cations and anions of the water matrix, this method is not applicable to natural waters. The main strategy with a sufficiently low identification limit in normal examples is a particle pair HPLC technique with precolumn development of the Fe(III)- edifices. In natural waters and wastewater, the phosphonates can be measured with a detection limit of 0.05 mM. The strategy, in any case, can't measure bisphosphonic acids like HEDP at low focuses. This is a significant disadvantage on the grounds that HEDP is one of the most utilized phosphonates [4,6]. After derivating the aldehyde group in FIDMP with 2,4-dinitrophenylhydrazine and derivating the imine-group in IDMP with 9-fluorenyl methylchloroformate, the breakdown products of the Mn(II)-catalyzed degradation of NTMP, iminodimethylenephosphonic acid (IDMP) and N-formyl-iminodimethylenephosphonic acid (FIDMP) have been accomplished. An identification breaking point of 0.01 mM FIDMP and 0.02 mM IDMP has been accomplished. Anion-exchange chromatography coupled to ICP-MS is capable is an extremely encouraging strategy for chelating specialist examination. It has been demonstrated that CuEDTMP can be determined with a very low detection limit in the nanomolar range, and the method is also applicable to phosphonates. Using various adsorbents, the preconcentration of phosphonates from natural water samples has been tested. It was found that the examined phosphonates HEDP, NTMP, and EDTMP contrasted such a great amount in their compound way of behaving that a synchronous improvement from regular examples can't be accomplished. Fruitful preconcentration of the phosphonates NTMP, EDTMP and DTPMP from regular waters or wastewaters was accomplished utilizing newly encouraged CaCO<sub>3</sub>. An influent sample from a wastewater treatment plant had

recoveries ranging from 95 to 102% at the 1 mM level.

## 2. Concentrations in the Environment

There have been no reports of measurements of phosphonates in natural samples, and only data for wastewaters are available. This is primarily because the majority of analytical techniques are unable to quantify phosphonates at low concentrations in natural waters. Phosphonates have been measured in Swiss wastewater treatment plants (WWTP). The concentrations of NTMP were somewhere in the range of 0.05 and 0.85 mM, of EDTMP somewhere in the range of 0.05 and 0.15 mM and of DTPMP somewhere in the range of 0.05 and 1.7 mM. The most elevated grouping of DTPMP was found in a WWTP impacted by material industry. With the exception of one instance, all of the investigated WWTP's effluent samples were always below the detection limit. One more WWTP impacted by material industry contained NTMP fixations in the influent somewhere in the range of 0.2 and 1.1 mM. In the influent of two WWTPs, the oxidative breakdown products of NTMP, IDMP, and FIDMP were found at concentrations of 0.08 and 0.015 mM FIDMP and 0.49 and 0.3 mM IDMP, respectively. With adsorption/photodegradation, the expected concentrations in rivers are as low as 0.1 mM, with NTMP reaching 1–4 nM and HEDP reaching 25 nM [6,7]. Intermittent cooling tower water discharge is expected to result in locally higher concentrations.

## IV. SURFACE REACTIONS

### 1. Adsorption

Phosphonates adhere to almost all mineral surfaces with a very strong adhesion. They behave differently from their aminocarboxylate counterparts, which have a much weaker interaction with mineral surfaces, particularly near neutral pH. A portion of the explored adsorbents for phosphonates are calcite, clays, aluminum oxides, iron oxides, barite, hydroxyapatite, and zinc oxide. In the pH range of natural waters, very strong adsorption is observed for all those compounds. Sludge from sewage, sediments, and soils, for example, are examples of natural materials that are

also very effective phosphonate adsorbents. However, the majority of these studies have not taken into account the possibility that metal ions might significantly alter a chelating agent's adsorption. Be that as it may, no impact of Fe(III), Zn, and Cu(II) on phosphonate adsorption onto goethite was noticed. This was explained by the extremely impressive adsorption of the uncomplexed phosphonate, which brought about a separation of the complex at the surface and separate adsorption of the metal and the phosphonate onto various surface locales. The adsorption of NTMP and the NTMP buildings with Zn, Cu and Fe(III). Complete adsorption is seen up to a pH of 8 and no impact of the complexed metal on the state of the adsorption edge should be visible. As a result, adsorption is very strong at natural water's pH. Other phosphonates, for example Adsorption by HEDP, EDTMP, and DTPMP is comparable to that of NTMP. Ca meaningfully affects phosphonate adsorption. Within the sight of mM Ca concentrations, phosphonates were totally adsorbed up to pH of 12. In the presence of Ca, the maximum surface concentration of phosphonates was also significantly increased. This impact can be made sense of by the development of ternary surface-phosphonate-Ca buildings. It is possible to rule out Ca-phosphonate precipitation on the surface. While assessing the adsorptive limit of a surface towards phosphonates in a characteristic framework.

### 2. Dissolution of Minerals

Disintegration of a mineral stage by chelating specialists can be explained in terms of a ligand exchange cycle and is connected with the convergence of surface bound ligands. The ligands debilitate the metal-oxygen bonds on a superficial level and improve the arrival of metal particles from the surface into the nearby arrangement. Responses with iron oxides are particularly critical in regards to the speciation of the ligand in arrangement due to the exceptionally amazing Fe(III)-edifices. Similar reactions have been observed in subsurface systems and have a significant impact on heavy metal mobility. Very little is had some significant awareness of the disintegration of iron oxides by phosphonates. Although it was observed that HEDP

significantly mobilized Fe from natural sediments, the pH value of the experiments was not specified. At pH 3, 0.01 M NTMP did not increase the solubility of Fe in river sediment. When the stability constants of the Fe(III)-complexes are known, the concentration of the Fe(III)-complex in the presence of an iron oxide phase can be calculated. This figure depicts the calculated concentration of the Fe(III)NTMP in a system containing NTMP and hydrous ferric oxide (HFO). The published metal-NTMP complex stability constants [12] and the NTMP-Fe(III) stability constants obtained from the ChemEQL software were used to calculate the speciation [13]. In the absence of any other metal ions, pH values below 6 are critical for the formation of Fe(III)NTMP. NTMP is present as an uncomplexed ligand at pHs above 7; the formation of Fe(III)NTMP is slightly slowed by 1 mM Ca and equimolar Zn. Cu which frames the most grounded edifices with NTMP has the biggest effect on Fe(III)NTMP arrangement. As a result, we can conclude that dissolution reactions can take place at low pH. However, because of the strong adsorption of phosphonates, particularly at low pH, the formation of dissolved Fe(III)NTMP complexes will be limited, and as a result, dissolution will not occur at low concentrations that are relevant to the environment.

### 3. Remobilization of Metals

Metals adsorbed onto a mineral surface can be solubilized by chelating specialists. One of the most detrimental effects of elevated chelating agent concentrations in the environment has always been cited as this process. Phosphate adsorption of metals has been investigated. Electrostatic effects lead to an increase in Cu adsorption at low pH when phosphonates are present. Cu is mobilized at high pH as a result of the formation of dissolved Cu-phosphonate complexes. illustrates how EDTMP affects Cu adsorption onto goethite. Generally, the impact of phosphonates on metal adsorption in the normal pH range from 4 to 8 is feeble. Therefore, we can anticipate that phosphonates have little effect on the remobilization of metals in natural systems. This was actually discovered during the PHASE HEDP study of metal mobilization from river sediments. Zn, Cr, Ni, Cu, Pb, and Cd were not

increased in comparison to a blank sample, and only the dissolution of iron oxides was observed. The only metal that remobilized was Fe. Only at NTMP concentrations above 0.1 mM did Cu, Cd, and Pb remobilize in river sediment. compound water treatment added substances, known as "sift old inhibitors". Phosphonic acids, along with polyphosphates, are among the most effective scale inhibitors. At concentrations far below stoichiometric amounts of the reactive cations, they poison the growth of crystals. Inhibition of nucleation, adsorption onto growth sites, distortion of the crystal lattice, changes in surface charge, and association with crystal formation precursors are all models for this poisoning.

### 4. Precipitation

Phosphonates are added to waters with high concentrations of dissolved ions in many applications to prevent the formation of precipitates. However, the phosphonates themselves may precipitate because some metal-phosphonates are insoluble. This peculiarity frequently happens in oil field applications when phosphonates are infused into the subsurface and are left to cooperate with calcium-containing arrangement waters. The solvency of hastens of NTMP with divalent metals expansions in the request CaoBaoSroMg. In-depth research has been conducted on the DTPMP, NTMP, and HEDP insoluble Ca precipitates as well as the NTMP precipitates containing Fe(II) and Fe(III). Insoluble results of HEDP are likewise framed with weighty metals like Pb and Disc. Oil field applications and technical systems with simultaneous high phosphonate and ion concentrations rely heavily on the precipitates. In regular waters or wastewaters, the phosphonate or Ca concen-trations are very low to apply any effect on phosphonate fixations. Between 1 and 5 mM Ca, NTMP always has a solubility above 200 mM. Precipitation reactions are not important in natural waters.

### 5. Inhibition of Dissolution and Precipitation

Scale development, for example precipitation of calcium carbonate or calcium sulfate, is a huge issue in business water treatment processes including cooling water innovation, desalination

and oil field applications. This scale arrangement can be mitigated by the utilization of which gem development is significantly diminished. According to the Langmuir adsorption model, the compounds with the strongest inhibitory effect can be used to interpret the various phosphonate's ability to prevent crystal growth. It has been argued that phosphonates may hinder phosphate elimination through precipitation with iron or aluminum salts during wastewater treatment due to their inhibitory effect on crystal growth. It was discovered that the phosphonates had an effect on flocculation, but this effect could be mitigated by adding more flocculating agent. The dispersing action of the phosphonates stabilized the particles that precipitated and prevented them from being retained in the sand filter. However, HEDP did not appear to have any effect on phosphate elimination in another study.

## V. DEGRADATION

### 1. Biodegradation

Phosphonates are like phosphates with the exception of that they have a carbon-phosphorous (C-P) bond instead of the carbon-oxygen-phosphorous (C-O-P) linkage. Phosphonates frequently inhibit enzymes because of their structural similarity to phosphate esters and the high stability of the C-P bond. Bacteria play a significant role in the biodegradation of phosphonate in nature. The first phosphonate to be recognized to happen normally was 2-aminoethylphosphonic corrosive. It is found in plants and numerous creatures, for the most part in membranes. Phosphonates are found in a wide variety of organisms, including prokaryotes, eubacteria, fungi, mollusks, insects, and others. However, the biological function of the naturally occurring phosphonates is not fully understood. Because of the presence of normal phosphonates in the climate, microorganisms have developed the capacity to process phosphonates as supplement sources. Phosphate can be used as a source of growth phosphorous by bacteria that can break the C-P bond. Some bacteria can also use amino phosphonates as their only source of nitrogen. The polyphosphonate chelating agents discussed here

are much larger, have a high negative charge, and are complexed with metals, making them distinct from natural phosphonates like 2-aminoethylphosphonic acid. Using sludge from municipal sewage treatment plants and HEDP and NTMP, biodegradation tests revealed no CO<sub>2</sub> formation evidence. An examination of HEDP, NTMP, EDTMP and DTPMP in standard biodegradation tests likewise neglected to distinguish any biode-degree. However, it was noted that the test substance was removed from solution as loss of DOC in some tests due to the high sludge to phosphonate ratio. This was ascribed to adsorption as opposed to biodegradation on the grounds that no going with expansion in CO<sub>2</sub> was noticed. In any case, bacterial strains fit for debasing aminopolyphosphonates and HEDP under P-restricted conditions have been detached from soils, lakes, squander water, enacted slime and fertilizer. Under conditions of low phosphate availability, microbial enrichment cultures from a variety of ecosystems also rapidly degraded the phosphonate phosphonobutanetricarboxylic acid (PBTC). The environmental impact of phosphonate uptake and degradation is greatly influenced by other P sources that are easier to access. P is rarely lacking in many environments that serve as sinks for phosphonates, such as activated sludge, sediments, and soils. Since phosphonates are used solely as P-source, little biodegradation can be anticipated under these circumstances. However, it has been demonstrated that bacteria can utilize phosphate and phosphonate simultaneously. Adsorption of chelating specialists by surfaces has been displayed to diminish the biodegradability. The effectively biodegradable NTA for instance is a lot more slow corrupted when adsorbed to mineral surfaces. Phosphate degrading much more slowly in a heterogeneous system than in a homogeneous one is to be expected due to their greater surface affinity. The phosphonate-containing herbicide glyphosate, N-phosphonomethyl-glycine, was found to be the culprit in this situation. Phosphonates are consequently like EDTA in that practically no biodegradation is seen in regular frameworks however that microorganisms have

been segregated from these conditions equipped for debasing the compound.

## 2. Photo Degradation

The environment's removal of aminopolycarboxylates involves photo degradation of the Fe(III)-complexes. The reactivity of phosphates is comparable. In refined water and within the sight of Ca no photo degradation of HEDP was noticed except for the expansion of Fe(III) and Cu(II) brought about quick photograph corruption. Fe(III)EDTA photo degradation is comparable to the mechanism of Fe(III)EDTMP photo degradation. From the parent compound, Fe(III)EDTMP is degraded in steps from ethylenediaminetrimethylenephosphonate to ethylenediaminedimethylenephosphonate, which is stable in the presence of Fe(III) and light, to ethylenediaminemo- nomethylenephosphonate. In natural waters, the primary method of EDTA elimination is the photo degradation of the Fe(III)-complexes. As a result, we can anticipate that photo degradation plays a significant role in determining what happens to dissolved phosphonates in surface waters. The photograph corruption results of Fe(III)EDTA are promptly biodegradable, yet this isn't true for phosphonates.

## 3. Chemical Degradation

Phosphonates are truly steady and breakdown of uncomplexed phosphonates requires long timescales and serious substance conditions. Free NTMP breaks down into a variety of breakdown products at temperatures above 200 degrees Celsius. These circumstances are significant for the destiny of the chelating specialists in specialized frameworks at raised temperatures, for example in cooling waters of force plants, yet not so much for regular waters. One review performed at room temperature inside the pH scope of 2-10 detailed that north of a multi month time span, EDTMP hydrolyzed under development of phosphate, phosphite and hydroxymethylphosphonate (HMP). Other breakdown products containing phosphonate were sent ahead of time, but they were not identified. There was no mention of the kinetics or the percentage degraded. Chelating agents and, consequently, phosphonates always

occur as metal complexes in natural waters. Therefore, the presence of metals ought to always be taken into account in studies of the chemical degradation of phosphonates. In metal-ion free oxygenated solutions, degradation of the amine linkage-containing phosphonates NTMP, EDTMP, and DTPMP was negligible; however, Ca, Mg, and Fe(II) caused conversion to free phosphate at a rate of approximately 1% per day. Even though the degradation was categorized as hydrolysis, in the absence of oxygen, the conversion rate dropped to negligible levels, indicating that redox reactions were involved. Degradation of HEDP, which lacks an amine linkage, occurs approximately 20 times more slowly. A deficiency of NTMP in various regular waters (waterway waters, groundwaters) and presence of the degrada-tion items has been noticed. Abiotic hydrolysis, followed by aminomethylphosphonate (AMPA) and CO<sub>2</sub> conversion, and microbial degradation were cited for the transformation of NTMP into iminodimethylenephosphonate (IDMP) and HMP, respectively. In a medium that did not contain any microorganisms but did contain trace amounts (0.1 mM) of Fe(III), Cu(II), Mn(II), and Zn, the authors conducted a follow-up study. Within 32 hours, NTMP, IDMP, HMP, and AMPA were transformed completely. The catalytic agent could not be identified due to the presence of multiple metal ions in these investigations. The effect of metal ions on the breakdown of phosphonate has been the subject of a systematic investigation. Contrary to previous findings, in which NTMP degradation was observed in the presence of Ca or Mg, no breakdown of NTMP was observed in metal-free systems or in the presence of Ca, Mg, Zn, Cu(II), or Fe(III). In the presence of Mn(II) and molecular oxygen, aminopolyphosphonates went through a very rapid degradation process. At pH 6.5, the reaction of NTMP in equilibrium with 0.21 atm O<sub>2</sub> and equimolar Mn(II) lasted for 10 minutes. The response happens all the more leisurely under additional basic or acidic circumstances. There was no reaction in the absence of oxygen, indicating that an oxidation step was involved. The presence of different cations like Ca, Zn, and Cu(II) can significantly dial back the response by contending with Mn(II) for NTMP. Synergist Mn(II) is recovered

by oxygen in cyclic style as the response happens. The oxidation of Mn(II)-phosphonate to Mn(III)-phosphonate by molecular oxygen is the proposed route. In an intramolecular redox-response the Mn(III) oxidizes the phosphonic corrosive and is thusly diminished to Mn(II). Formate, orthophosphate, IDMP and FIDMP separate items have been distinguished. Mn(III)-containing manganite (MnOOH) breaks down both in oxygen-free suspension and when MnOOH is in contact with oxygen. In the presence of oxygen and Mn(II), EDTMP and DTPMP are also degraded, albeit at a slower rate than the amine-free HEDP. Two of the breakdown results of NTMP, IDMP and FIDMP, have been recognized in WWTP. This suggests that the manganese-catalyzed oxidation of aminopolyphosphonate in natural waters is probably a significant degradation mechanism.

#### 4. Degradation During Oxidation Processes

Phosphonates present in normal waters might be dependent upon oxidation and sanitization processes during drinking water treatment. There is no available data on how phosphonates behave during chlorination. 60–70% of the degraded phosphonate was found as phosphate, and AMPA and phosphonoformic acid were also found. Ozonation of NTMP, EDTMP, and DTPMP resulted in the rapid disappearance of the parent compound in less than a minute. Only 15% of the amine-free HEDP was degraded after 30 minutes, which is a significantly slower rate. During ozonation, EDTMP behaves in a manner that is analogous to that of EDTA. The herbicide glyphosate was produced at concentrations of up to 10 nM during ozonation of EDTMP. Both AMPA and glyphosate's environmental fate, behavior, and analysis have received a lot of attention [10]. The formation of these compounds during ozonation of an aminopolyphosphonate may significantly alter the risk analysis of these compounds.

## VI. CONCLUSION

1. The exceptionally amazing adsorption of phosphonates brings about low broken up fixations.

2. Phosphate remobilization of metals is unlikely to occur.
3. No biodegradation of phosphonate-chelating specialists is seen in the climate.
4. The Fe(III)- buildings are quickly photo degraded.
5. In the presence of Mn(II), aminopolyphosphonates undergo rapid degradation.
6. There is a pressing need for an analytical method for measuring trace elements in natural waters.
7. There is no analytical data on the environmental speciation of phosphonates.

## REFERENCES

1. Means JL, Alexander CA. The environmental biogeo- chemistry of chelating agents and recommendations for the disposal of chelated radioactive wastes. *Nucl Chem Waste Manage* 1981;2:183–96.
2. Wolf K, Gilbert PA. EDTA— Ethylenediaminetetraacetic acid. In: Hutzinger O (Ed.), *The Handbook of Environ- mental Chemistry*, vol. 3, Part F. Berlin, Heidelberg: Springer, 1992. p. 243–59. Bucheli-Witschel M, Egli T. Environmental fate and microbial degradation of aminopolycarboxylic acids. *FEMS Microbiol Rew* 2001;25:69–106.
3. Knepper TP, Weil H. Study on the entry of synthetic chelating agents and compounds exhibiting complexing properties into the aquatic environment. *Vom Wasser* 2001;97:193–232.
4. Nowack B. Environmental chemistry of aminopolycarboxylate chelating agents. *Environ Sci Technol* 2002;36: 4009–16.
5. Gledhill WE, Feijtel TCJ. Environmental properties and safety assessment of organic phosphonates used for detergent and water treatment applications. In: Hutzinger O, editor. *The handbook of environmental chemistry*, vol. 3, Part F. Berlin, Heidelberg: Springer, 1992, pp. 261–85.
6. Jaworska J, van Genderen-takken H, Hanstveit A, van de Plasche E, Feijtel T. Environmental risk assessment of phosphonates, used in domestic

- laundry and cleaning agents in the Netherlands. *Chemosphere* 2002;47:655–65.
7. Atkinson D. Toxicological properties of glyphosate—a summary. In: Atkinson D, editor. *The herbicide glyphosate*. London: Butterworths, 1985. p. 127–33.
  8. Franz JE, Mao MK, Sikorski JA. Glyphosate: a unique global herbicide. *ACS Monogr* 1997;189:653.
  9. Stalikas CD, Konidari CN. Analytical methods to determine phosphonic and amino acid group-containing pesticides. *J Chromatogr A* 2001;907:1–19.
  10. de Klerk JMH, van Dijk A, van het Schip AD, Zonnenberg BA, van Rijk PP. Pharmacokinetics of rhenium-186 after administration of rhenium-186-HEDP to patients with bone metastases. *J Nucl Med* 1992;33: 646–51.
  11. Popov K, Ro. nkko. ma.ki H, Lajunen L. Critical evaluation of stability constants of phosphonic acids. *Pure Appl Chem* 2001;73:1641–77.
  12. Müller B. ChemEQL, 2.0 A program to calculate chemical speciation, equilibria, titrations, dissolution, precipitation, adsorption, simple kinetics, px-py diagrams. EAWAG/ ETH, 1996.
  13. Fleisch H. Bisphosphonates: a new class of drugs in diseases of bone and calcium metabolism. *Recent Results Cancer Res* 1989;116:1–28.
  14. May HB, Nijs H, Godecharles V. Phosphonates. Multi-functional ingredients for laundry detergents. *Household Pers Prod Ind* 1986;23:50–4.
  15. Davenport B, DeBoo A, Dubois F, Kishi A. CEH report: chelating agents. SRI Consulting, Menlo Park, CA, USA, 2000.
  16. van Hullebusch E, Chazal PM, Deluchat V. Influence of phosphonic acids and EDTA on bacterial copper toxicity. *Toxicol Environ Chem* 2002;82:75–91.
  17. Huber L. Investigations about the biological degradability and fish toxicity of 2 organic chelating agents on phosphonic acid basis (ATMP and HEDP). *Tenside Deterg* 1975;12:316–22.
  18. Schoberl PH. Ecologically relevant data of non-tenside de-components in washing and cleaning agents. *Tenside Surfactants Deterg* 1988;25:99–107.
  19. Steber J, Wierich P. Properties of hydroxyethane diphosphonate affecting its environmental fate: degradability, sludge adsorption, mobility in soils, and bioconcentration. *Chemosphere* 1986;15:929–45.
  20. Steber J, Wierich P. Properties of aminotris(methylene phosphonate) affecting its environmental fate: degradability, sludge adsorption, mobility in soils, and bioconcentration. *Chemosphere* 1987;16:1323–37.
  21. Calvin G, Long PH, Stitzel KA, Anderson RL, Balmbra RR, Bruce RD, Bhatt A, Miller PM, Broad meadow A. Ethylenediaminetetra(methylenephosphonic acid) — genotoxicity, biodistribution, and subchronic toxicity in rats. *Food Chem Toxicol* 1988;26:601–10.
  22. Francis MD, Centner RL. The development of diphosphonates as significant health care products. *J Chem Educ* 1978;55:760–6.
  23. Weiss J, Hägele G. Ion-chromatographic analysis of inorganic and organic complexing agents. *Fresenius Z Anal Chem* 1987;328:46–50.
  24. Tschabunin G, Fischer P, Schwedt G. On the analysis of polymethylenephosphonic acids. I. A systematic survey of the ion chromatography of organophosphonic acids. *Fresenius Z Anal Chem* 1989;333:111–6.