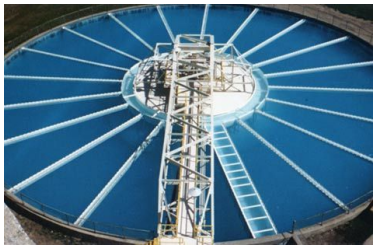
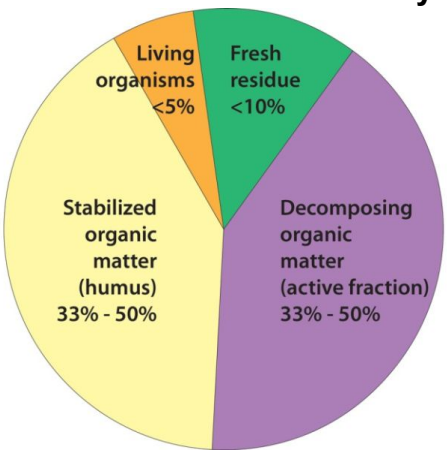
Water Purification

ClearValue® provides a complete purification solution. **ClearValue®** water purification systems comprise complete chemical and filtration solutions that provide the purest of water at significantly reduced purification cost. **ClearValue®** water purification systems are further a complete approach to removal of Total Organic Carbon (TOC) and therefore disinfection by-products (DBPs).



ClearValue® leading coagulation systems produce filtered water at less than 0.1 Nephelometric Unit (NTU) and 5 Color Units by producing clarified water at less than 1.0 NTU and 15 Color Units (remaining NTU and Color is removed in filtration). In addition to water quality, this chemistry provides further benefits, i.e. elimination or reduction of pretreatment cost and associated contamination, reduction or elimination of pH adjustment cost, improved filter life, elimination of ammonia disinfection, reduced chlorine disinfection and a minimum 60 percent sludge volume reduction. Improved filter life is performed by elimination of pin floc.

TOC and its removal are relatively new concepts for the drinking water industry. First and foremost, TOC molecules are precursors to DBP(s). There has been much research to reveal DBP(s) as toxic, carcinogenic and teratogenic. Moreover, it only follows by common sense that this would be so. Cells consume TOC as food; that is how our bodies work. Further, disinfectants are used to kill microorganisms (viruses and bacteria) to protect our bodies therefrom. It is only common sense that DBP(s), which are a combination of TOC with a disinfectant, would be harmful. Finally, the combination pathway, nucleophilic substitution, has been well known in organic chemistry since the 1940's. Nucleophilic substitution can be referenced in any organic chemistry text or handbook. *Hawley's,* **Condensed Chemical Dictionary**, Twelfth Edition defines – nucleophile: *An ion or molecule that donates a pair of electrons to an atomic nucleus to form a covalent bond*. The nucleus that accepts the electrons is called an *electrophile*. *All disinfectants are nucleophiles and nearly all TOC compounds are electrophiles.* An in depth understanding of DBP(s) and nucleophilic substitution in water chemistry can be obtained from **Formation and Control of Disinfection By-Products in Drinking Water**, by Dr. Philip C. Singer, published by *The American Water Works Association*.



TOC may consist of various organic molecules that ClearValue® distinguish into the categories of Insoluble Organic Carbon (IOC) and Soluble Organic Carbon (SOC). Most have heard of DOC (Dissolved Organic Carbon), which is defined as the portion of TOC which will pass through a 0.34 micron filter; however, such is a test for molecular size and not a test for solubility. *The industry laboratory test, then, defines DOC as both IOC and SOC; this is confusing.* IOC molecules because of insolubility and the resulting water columbic charge are easily removed via ClearValue® coagulation and flocculation chemistry. SOC molecules, however, are soluble thereby having no columbic charge and are thereby difficult to remove via coagulation and flocculation. SOC molecules are either polar, such as acids or alcohols, or very small, C1 to C3 molecules. Insolubility and solubility can be referenced in any General Chemistry or Organic Chemistry text.

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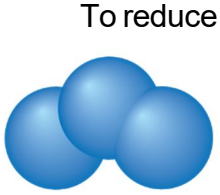
Tabulated solubility values can be referenced in **CRC Handbook of Chemistry and Physics,** any edition, *CRC Press*. Further, just by size, the kinetics required to contact the coagulant with these SOC molecules is greater than that available in drinking water mixing and coagulation systems.

Not having a good understanding of IOC versus SOC, most municipalities only measure TOC while not realizing that TOC = SOC + IOC. Also, most do not realize that the industry analytical test for DOC is actually a measure of molecular size and not of solubility (0.34 micron filter). And, most importantly, due to solubility, the coagulant is incapable of removing most, if not all, of the SOC molecules; while due to insolubility, the coagulant is capable or removing most, if not all, of the IOC molecules. A better understanding of the coagulant's inability to remove TOC would be to analyze the raw water for its SOC fraction. This is best accomplished with a Gas Phase Chromatograph (GPC) or a Liquid Phase Chromatograph (LPC). The SOC content is approximated by the SUVA calculation. SUVA = UV^{254} /DOC. Most important, **TOC = SOC + IOC. And, SOC can only be accurately measured with a GPC or LPC.**

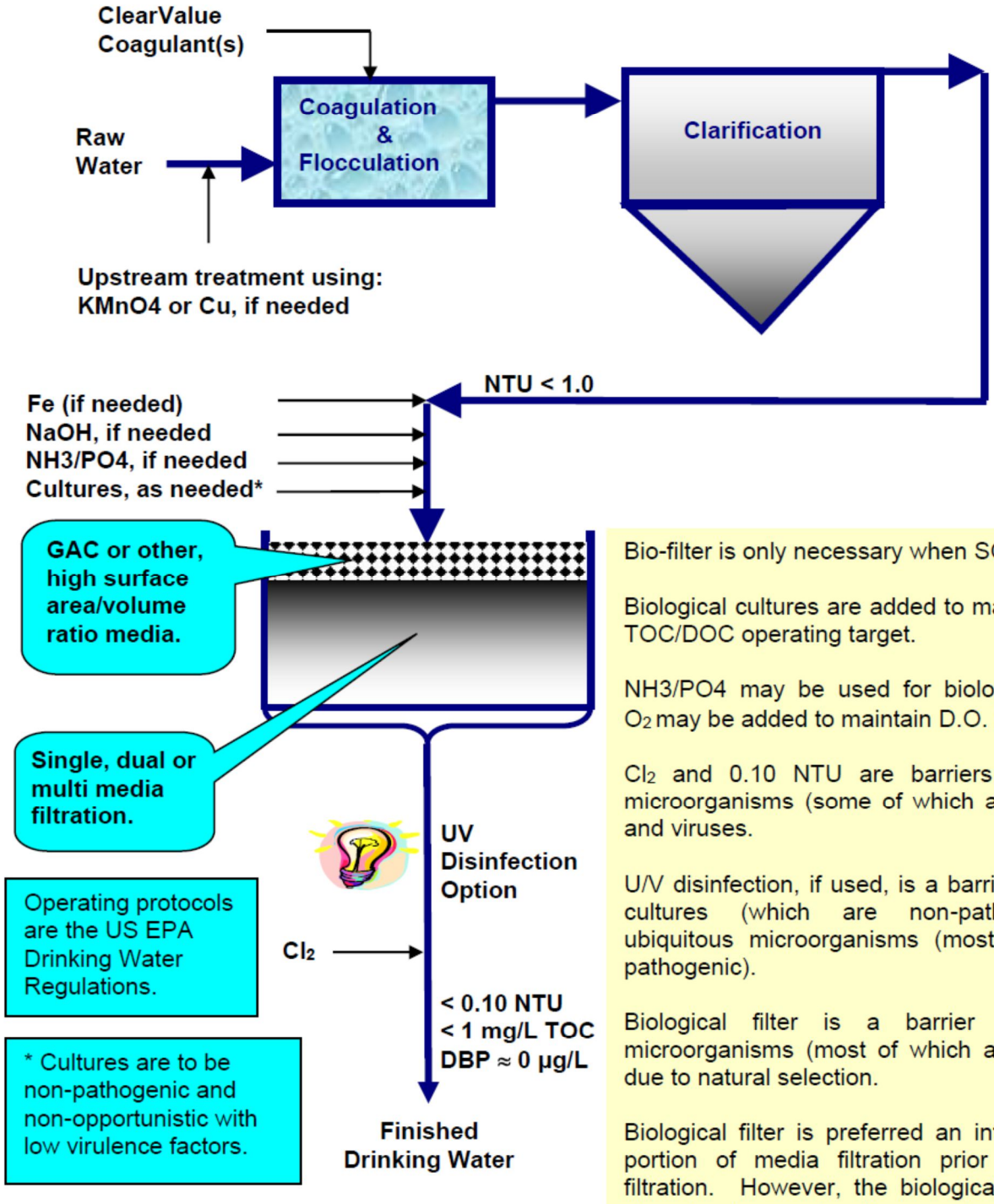
To reduce DBPs, many water production facilities have invested in ozone (O_3) production plants for on-site O_3 production and water disinfection. However, O_3 is an expensive chemical having its own set of DBP(s), namely glycols, organic acids, aldehydes and ketones; none of which are regulated. Water production facilities which install O_3 generators significantly increase operating cost. Further, most of these O_3 disinfection systems operate with a poorly performing ubiquitous biological filter (UBF) downstream of ozonation, coagulation and separation; these UBF allow biological cultures from the watershed to grow on the filter media (again, downstream of ozonation, coagulation and separation). In such facilities, less than 1 mg/L of SOC removal occurs across the UBF; further, nearly all UBF SOC removal is AOC (Assimulatable Organic Carbon). AOC molecules are primarily alcohols; UBF cannot remove toxic, carcinogenic or teratogenic DBP(s). At ClearValue, we believe that UBF are inherently dangerous by: growing pathogens on the UBF (again, downstream of ozonation, coagulation and separation), having no control of biomass, having no control of SOC removal and having little to no removal of toxic, carcinogenic and teratogenic DBP(s). Instead of O_3, other facilities are pre-treating with chlorine dioxide (ClO_2). ClO_2 creates a set of DBP(s) which is very similar to those of O_3; again, none of which are regulated. Still yet, other facilities, including O_3 facilities, are converting to chloramine ($ClNH_2$) disinfection. $ClNH_2$ creates carcinogenic nitrosamines, which are not regulated. In conclusion, all that is accomplished with $ClNH_2$, O_3 and ClO_2 treatment is to bypass regulations, while creating carcinogenic, teratogenic and toxic DBP(s), none of which are regulated or monitored.



ClearValue's proprietary Enhanced Biological Filtration (EBF) technology has demonstrated *SOC and DOC removal performance to 1 mg/L utilizing nature's biological water purification processes*, as well as NTU reduction *(pathogen removal*) due to the process of *natural selection*. EBF is accomplished utilizing known non-pathogenic, beneficial, cultures raised in a fermentation device to be certain of colonies placed on the biological filter (much improved over UBF). EBF is managed by the measurement of TOC downstream of filtration and controlled by the addition of the beneficial cultures to the enhanced biological filter. In EBF, literally, beneficial cultures eat the TOC from the water for a much purer water, just like nature. Turbidity removal and disinfection are performed with the drinking water regulations as operating protocol.

ClearValue® EBF is Nature's method of water purification with a beneficial improvement!

Drinking Water Purification Process Flow Diagram



Bio-filter is only necessary when SOC > 2.0 mg/L.

Biological cultures are added to maintain the final TOC/DOC operating target.

NH3/PO4 may be used for biological nutrients. O_2 may be added to maintain D.O. ≥ 0.3 mg/L.

Cl_2 and 0.10 NTU are barriers to ubiquitous microorganisms (some of which are pathogenic) and viruses.

U/V disinfection, if used, is a barrier to biological cultures (which are non-pathogenic) and ubiquitous microorganisms (most of which are pathogenic).

Biological filter is a barrier to ubiquitous microorganisms (most of which are pathogenic) due to natural selection.

Biological filter is preferred an integral and first portion of media filtration prior to final NTU filtration. However, the biological filter may be placed at any location upstream of media

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