Pressures in construction phase MRE - Electromagnetic radiation, turbidity and noise

Background document

ResponSEAble project WP 5, deliverable 5.5: Educational packages for professionals

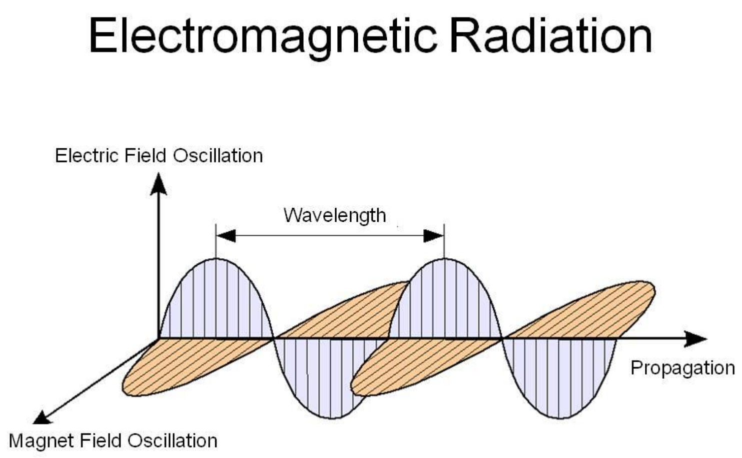
Produced by: ProSea Foundation, marine education (www.prosea.info)

1. Electromagnetic radiation

It was thought once that electricity and magnetism are separate forces. However, the study of electromagnetism covers the interaction of electrically charged particles with magnetic fields. Electromagnetic radiation is a combination of an atomic particle (an electron for example) accelerated by an electric field. This leads to a transverse wave of electric and magnetic fields, that are always at a 90-degree angle of each other and are always in phase (See figure 1). The movement of the radiation is the fastest one possible in the known universe with almost 300,000 km per second, or in other words, the speed of light.

The characteristics of these fields and their waves are measured in frequency or wavelength.

One wavelength is the distance, usually in meters or fractions of this, between two peeks of a wave. The shorter the distance between peaks, the higher the frequency. Frequency measures the time it takes to form a number of waves. The higher the frequency, the more energy it carries.



Picture 1- the interaction between electricity and magnetic fields (cmditradmin)

All these wavelengths and frequencies are on an electromagnetic (EM) radiation spectrum, which has an enormous range (See figure 2). The range is divided in seven subranges in order of increasing wavelength and decreasing frequency and energy.

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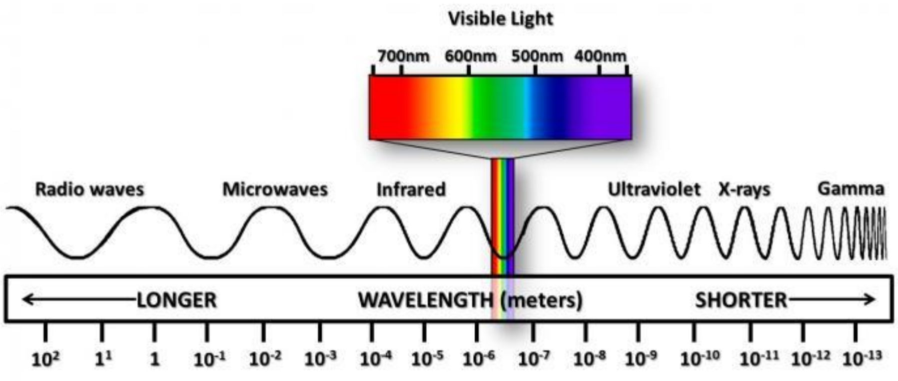
- **Radio:**
  These waves fall in the lowest range of the spectrum, and are primarily used for transmitting voices, music and data.
- **Microwaves:**
  These waves are used for higher bandwidth communications, radar and as a heating source.
- **Infrared:**
  This is the first spectrum that can be detected with human senses. Although it is still invisible to the human eye, we can feel it as heat.
- **Visible light:**
  The light we see is also made up of EM radiation. It falls in the middle of the spectrum and ranges from about 400 terahertz to 800 terahertz (TH).
- **Ultraviolet:**
  Ultraviolet light is a component of sunlight, even though it is invisible to the human eye. It is also the first range in the spectrum that has a high enough frequency to damage living tissue at a molecular level.
- **X-ray and gamma ray:**
  These waves are on a frequency so high that they are called ionizing radiation. This means that they contain energy large enough to liberate the photons from the atom. These waves are capable of the most severe type of molecular damage like causing cancer. Fortunately, most of these waves are blocked from entering the atmosphere by the ozone layer.



Picture 2- Electromagnetic spectrum with seven ranges (Climate Science Investigations)

EM of underwater electricity cables varies in strength depending on cable design, depth of burial and water depth. The deeper a cable is buried the weaker the EM at the sea bottom. And the shallower the water the bigger the chance that EM field may reach the sea surface. If that occurs, an electricity cable may act as a barrier for certain marine species to cross or pass. It is known that particularly sharks and ray are sensitive species. Detailed qualification or quantification of this type of impacts in being studied, but in general scientific information is very scarce.

2. Turbidity

Turbidity is the opposite of clarity. It is determined by the number of particles in any fluid. These particles can be visible by the naked eye or not. If they are visible and larger of size and density, they will often sink to the bottom. The smaller particles will sink slower or not at all and cause the light that falls through to be disturbed, making the fluid turbid. It can also be applied to transparent solids like glass and plastic.

Materials that can cause turbidity in the ocean include but are not limited to finely divided organic and inorganic material, clay, silt, plankton and other microscopic organisms.

Turbidity is a natural phenomenon in many ecosystems. Estuaries (where fresh and salt water meet) are known for high, natural turbidity values. Also, wind, waves and storms can lead to naturally high turbidity, e.g. in shallow waters with soft bottoms. In those areas, species are generally fairly well adapted to high turbidity and have high tolerances. In other areas, turbidity can be very damaging, e.g. in coral reefs, which require clear water and the radiation of the sun to flourish and stay healthy.

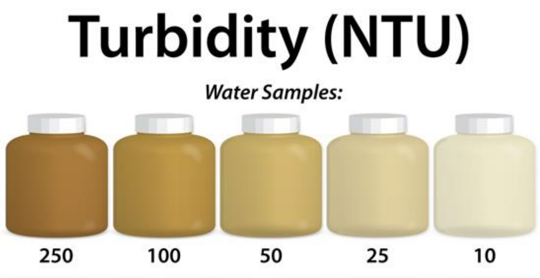
Picture 3- Turbidity in sediment laden river (City of Tuscaloosa)

Turbidity is most commonly expressed as Nephelometric Turbidity Unit (NTU), or Jackson Turbidity Unit (JTU). These are very important in water quality tests.

- NTU is measured by sending light at right angles through a water sample. Measuring the scattering of the light can be translated to a concentration of suspended particles in the water expressed as NTU.
- JTU is traditionally measured by taking the distance of a water column though which the flame of a candle can be seen. The greater the distance, the clearer the water. The candle is not used anymore in modern science, but the technique remains the same and should still be noted in JTU.

Not all particles in fluid are bad or toxic, but because it is almost impossible to eliminate specific particles, (almost) all water bodies have turbidity standards to which they have to comply. The most important one being drinking water. Each country has different water quality criteria for turbidity, but the World Health Organization states that drinking water worldwide should not exceed 5 NTU and should ideally be below 1 NTU.

Ambient water standards are determined differently per country or state/province.



Picture 4- Turbidity measured in NTU

Treatment of turbidity is commonly done by filtration or settling. The settling process can be aided by adding chemical reagents that attach to the particles and make them heavier, which speeds up the settling. It depends on the application of the water if the reagents can be applied.

If not treated properly, turbidity can even inhibit photosynthesis by blocking sunlight. In areas where this is a permanent state of the water body, the underwater vegetation is using the dissolved oxygen (DO) in the water to survive and grow instead of using photosynthesis. This means the DO level drops, and the organisms that rely on oxygen either move away or deplete. A cascade effect develops when the vegetation eventually dies off, because the decomposition of the plants drops the DO even further.

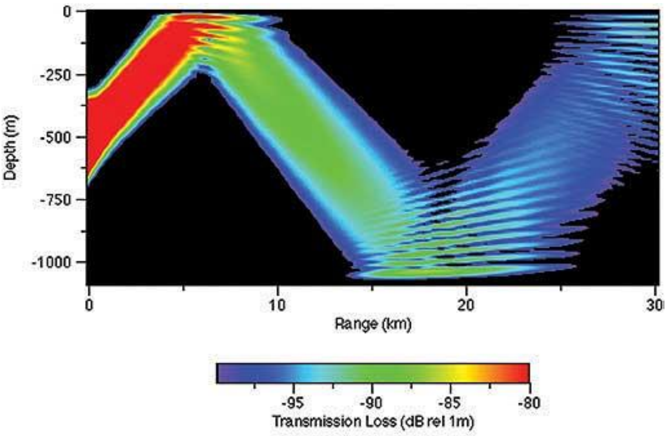
3. Underwater noise

Underwater acoustics are studied since 1490 and entail the study on propagation of sound under water, and how it transforms going from one point to another.

Like acoustics in air, underwater acoustics are created by sound waves. Underwater these are formed by alternating compressions and rarefactions of the water. A receiver detects these as changes in pressure.

The speed with which these waves move is determined by temperature, salinity and pressure of the water. In normal ocean water the speed lies between 1490 meter/seconds and 1620 m/s. It propagates until the waves are fully absorbed by their environment, and because there are few obstacles in the open ocean, this means sound can travel for hundreds of miles.

In water, sound travels much faster and much further that in air.



Picture 5- Output of a computer model of underwater acoustic propagation in a simplified ocean environment (R.A. Zingarelli and D.B. King)

Marine animals have been using this technique for millions of years for various reasons, with the most important one being communication, with either other organisms or with the environment for echolocation.

Because sound waves travel so efficiently, marine animals are able to gather a lot of information about their environment from underwater sound. For some species this is crucial for determining their location, finding food or communication. Some species are more sensitive than others. Salmon for instance are not relying on sound, because hearing is of little use in the turbulent waters that they migrate to for spawning.

Each species will have different effects of changes in their environment.

A lot of studies have been conducted towards the impact of specific noises (Construction of offshore installations, shipping, sonar, etc) on area specific species. But due to the extensive range which the sound waves can travel, more research is needed on the cumulative effect of these sour