WATER INTERFERENCES: DEFINITION, LOCATION, NATURE OF PROCESS AND INDUCED EFECTS

V.SOROCOVSCHI[1]

Abstract.– **Water interferences: definition, location, nature of process and induced effects.**this study approaches a less studied category of water hazards – water interferences. The study analyzes some aspects. At the beginning is given a definition for water interferences and a mention is made about their complex characteristics. It is emphasized the process nature (physical, chemical, mechanical etc.) and the environmental effects of water interferences.

1. The definition for water interference and origin of interfering waters

Water interference represents a phenomenon of overlapping, compounding, interpenetration, combining, intercrossing of two water masses with distinct characteristics (physical, chemical, mechanical and dynamic), that join in some point of the propagation environment.

Interference phenomenon takes place in the marine environment near the coast (beaches, deltas, estuaries, lagoons, mangroves) and from deep waters, and also in the continental environments (over and underground).

The origin of interfering waters can be natural or artificial. The artificial ones are represented by the mine waters that came from ore mines (nonferrous deposits, gold-silver deposits, radioactive deposits), and from mineral fuels exploitation (oil, natural gas, coal) or their processing. The mine waters are able to influence the chemical composition and the toxically gas content of the waters they interfere with through the substances and gases they contain (H_2S, CO_2). The waters from rivers located in areas where building materials and some raw materials are exploited, contain a high level of suspended soils from exploiting depressions.

2. The nature and location of water interference induced processes

The processes that follow the interference phenomenon can have a physical, chemical, mechanical or environmental nature.

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[1] *ADIMITRIE CANTEMIR University, Faculty of Geography, TG.Mures, Romania, e-mail:*, sorocovschi@yahoo.com

2.1 Physical processes

Physical processes refer to the some physical water characteristics, such as *temperature, transparency and color*.

Because of the high warm water volume that flows into the rivers from power plants, the downstream sections have higher than average temperatures and a very low ice formation period, or even it doesn't exist.

River, lake and sea water temperatures highly depend on the drainage basin's climatic zone and on the tributaries water temperature. For example, the Danube's annual average water temperature is smaller in the upper section upstream Passau, because of the input with cool waters from the northern side of the Alps (Riss, Iller, Günz, Mindel, Lech, Issar and Inn). This phenomenon is more obvious in summer time, when water input is higher.

The thermal interference appears even in the underground world. Thermal waters have their source at depths with very high temperatures and they interfere when they reach the surface with low and medium depth underground waters.

The thermal marine interferences are very frequent and are very complex phenomena, with areal and local characteristics. The local nature appears in the case of hydro fronts that separate water masses thermal and salt characteristics. Such an example is the El Niño phenomenon caused by the local exchange between a cold current (Humbolt Current or The Current of Peru) with a warm current on the Peru's Pacific coast.

The complexity of the thermal interference phenomenon is given also by the appearance in ocean surface waters (oceanic troposphere) under the action of warm and cold currents, and in oceanic stratosphere, under the action of *deep currents* (thermal-salinity, vertical and compensation currents), that modify the normal vertical temperature and salinity distribution.

If there is a high salinity vertically homogeneous layer at the water surface, the thermal interference phenomenon cannot be present. This is the case for the salt lakes in Transylvania Depression where is present the heliothermal phenomenon.

Another *thermal water in*terference phenomenon is **upwelling**, that involves the wind driven movement of dense, cooler, nutrient-rich waters towards the ocean surface, replacing the warmer, usually nutrient-depleted surface water. The upwelling intensity depends on wind's strength and seasonal variations, and also on the *vertical water structure, on ocean bottom bathymetry variations* and on currents instability. In some areas, upwelling is a seasonal phenomenon, with periodic fishery production growth, similar to springtime blooming in coastal areas. The upwelling caused by wind is generated by temperature differences between warm, light costal air and cooler, denser sea air. At temperate latitudes this contrast has a high seasonal variability, with strong upwelling periods in spring and summer, decreasing or even disappearing in winter time. For example, the coast of Oregon presents a 6 months season with four or five upwelling periods separated by low upwelling periods. Unlike this, at tropical latitudes with more constant temperatures, upwelling periods are constant the entire year. Peruvian upwelling appears almost all the year, determining the apparition of one of the most productive world fisheries for sardines and anchovies.

In years with thermal anomalies, with weak or reversed easterly winds, the water that is brought to surface is much warmer and nutrient-depleted, causing a reduction of plankton's biomass and productivity. This phenomenon is known as El Niño – Southern Oscillation (ENSO). Peruvian upwelling is more vulnerable especially in these periods, causing extreme interannual productivity variability.

Bathymetric changes can also modify upwelling intensity. For example, a submarine ridge that extends from the coast brings more favorable upwelling conditions for surrounding areas. Usually, upwelling phenomenon starts in these areas and after that develops in other locations.

Upwelling appears in all oceans, with local or regional character. It can be classified after the temporal character into temporal and seasonal.

After its location, upwelling can be classified in many types related with the divergence of deeper, cooler and more nutrients-rich currents to surface. There are at least 5 types of upwelling: "coastal upwelling, large-scale wind-driven upwelling in the ocean interior, upwelling associated with eddies, topographically-associated upwelling, and broad-diffusive upwelling in the ocean interior" (http:/www.eu.wikipedia.org).

In the northern hemisphere, costal upwelling can be determined by Ekman transport, forming a 90° angle current. Costal upwelling is the best known upwelling type and most connected with human activities, because it affects the most important fisheries in the world. Wind-driven currents are diverted to the right of the winds in the Northern Hemisphere and to the left in the Southern Hemisphere due to the Coriolis Effect. The result is a mass surface water movement to the right under the wind angle, known as the Ekman transport. When this transport appears away from the coast, surface waters moving away are replaced by deeper, colder, and denser water.

Deep waters are rich in nutrients, including nitrate, phosphate and silicic acid, themselves the result of decomposition of sinking organic matter (dead/detrital plankton) from surface waters. When brought to the surface, these nutrients are utilized by phytoplankton, along with dissolved $CO2$ (carbon dioxide) and light energy from the sun, to produce organic compounds, through the process of photosynthesis. Upwelling regions therefore result in very high levels of primary production (the amount of carbon fixed by phytoplankton) in comparison to other areas of the ocean. High primary production propagates up the food chain because phytoplankton is at the base of the oceanic food chain. The food chain follows the course: Phytoplankton → Zooplankton → Predatory zooplankton → Filter feeders → Predatory fish.

In the world there are five major coastal currents associated with upwelling areas: the Canary Current (off Northwest Africa), the Benguela Current (off southern Africa), the California Current (off California and Oregon), the Humboldt Current (off Peru and Chile), and the Somali Current (off Western India). All of these currents support major fisheries. It also occurs in southeastern Brazil, more precisely in Arraial do Cabo (http:/www.eu.wikipedia.org).

Upwelling at the equator is associated with the Intertropical Convergence Zone (ITCZ) which actually moves and is often located north or south of the equator. Easterly winds blowing along the ITCZ in both the Pacific and Atlantic Basins move water to the right (northwards) in the Northern Hemisphere and to the left (southwards) in the Southern Hemisphere. If the ITCZ is displaced above the equator, the wind south of it becomes a southwesterly wind which drives water to its right, away from the ITCZ. No matter what is it location, this results in a divergence, with denser, nutrient-rich water being upwelled from below, making possible for the Pacific equatorial region to be detected from space as a broad line of high phytoplankton concentration.

Large-scale upwelling can be found also in the Southern Ocean. Here, strong westerly winds blow around Antarctica, driving a significant flow of water northwards. This is actually a type of coastal upwelling. Since there are no continents in a band of open latitudes between South America and the tip of the Antarctic Peninsula, some of this water is drawn up from great depths. In many analyses, the Southern Ocean upwelling represents the primary means by which deep dense water is brought to the surface. Shallower, wind-driven upwelling is also found in off the west coasts of North and South America, northwest and southwest Africa, and southwest Australia, all associated with oceanic subtropical high pressure circulations.

Some models of the ocean circulation suggest that broad-scale upwelling occurs in the tropics, as pressure driven flows converge water toward the low latitudes where it is diffusively warmed from above. The required diffusion coefficients, however, appear to be larger than are observed in the real ocean.

Local and intermittent upwellings may occur when offshore islands, ridges, or seamounts cause a deflection of deep currents, providing a nutrient rich area in low productivity ocean areas. Such examples include upwelling around the Galapagos Islands and the Seychelles Islands, which have major pelagic fisheries.

Upwelling can also occur when a tropical cyclone transits an area, usually when moving at speeds of less than 5 mph (8 km/h). The churning of a cyclone finally draws up cooler water from lower layers of the ocean. This causes the cyclone to weaken.

Artificial upwelling is produced by devices that use ocean wave energy or ocean thermal energy conversion to pump water to the surface. Ocean wind turbines are also known to produce upwelling. Ocean wave devices have been shown to produce plankton blooms.

Other natural water interference processes have impact on water's *transparence and color*. The transparence and color of river water can be strongly modified by the input of waters that come from mining areas (base metals, precious metals, fossil fuels and building materials).

The high content of wash load modifies the water's transparence and color. Such an example is Huang He River, also called The Yellow River, because it crosses the world's vastest loess plateau (Huangtu Plateau), transporting a huge quantity of wash load (1.1 bil. tones/year), half of it reaching the river mouth, reason why the that sea is called the Yellow Sea.

Thwart this case is the Yangtze River from south China, that is called the Blue River because of its high transparence waters due to big quantity of water derived from rain and melting snow.

Other regions, such as Amazonia, have rivers that bear the name of the materials its transport: brancos (yellow alluvia rivers) and rios negros (black water rivers that originate in swamps). (P.Gâştescu, 2009)

Silting is a physical process that consists in a sludging of solid particles in surface waters, but also in the underground ones. Most world *reservoirs* are highly silted, following the intense deforestation practices that have produced in the last decades in their drainage basins. The silting process intensity depends on the lake's bed dimensions, lake water volume, lake's position in drainage basin, the base level of the sector between two reservoirs, etc.

Lake's silting process triggers some negative effects, such as vegetation's growth in silting areas, followed by the limitation of water surface with its consequences. The most negative effect is the decrease of lake water.

Another interference type is the suspension loading.

2.2. Chemical processes

Many water interferences trigger chemical processes generated by natural and also human influenced factors.

Although water interferences have negative effects such as water pollution, we can talk about "natural pollution" (although it's a misnomer), in places where it is produced by natural interferences caused by the mobility of natural process contamination. This kind of interferences appear in various conditions : when *waters are crossing a soluble rocks area* (sulphates, radioactive rocks etc.), that determines surface or underground waters contamination; when *waters are crossing a erosion area,* that triggers a pollution with solid particles, especially when they are contaminated with various chemical fertilizers, or when there appear long time suspension fines (shale or clay); when *there appears an abundant aquatically vegetation* (fixed or floating), especially in low speed water flow rivers and lakes, triggering pollution phenomena that vary in time according to vegetation periods; when *river bank vegetation* produces pollution through leaves or plant falling (Heise 2003; Owens 2005; Babut şi al. 2007).

Diapir areas influence the underground or surface water chemism and quality through direct leaching of salt deposits caused by infiltration waters, and through ground-water supply, through river bed deepening into salt deposits, through washing of salt efflorescences by torrents flowing into the river.

Rivers crossing or supplying from a swampy area have a high acidity.

Natural processes can modify temporally and spatially regular water parameters, but the most negative impacts of water interferences are caused by human activities. Often, the pollution sources generate significant changes in qualitative water characteristics that influence water supplies. Most common water pollutions sources involve industrial, agricultural, household and municipal solid waste flowing into waters through leakings, infiltrations, direct injections etc., with a complex circuit of contamination's transport. Thermal pollution also brings pollution with metals and other substances, such as chlorides used in power plant water processing.

Coastal areas have frequent water interferences determined by exploitation of sand dune water. Following the lowering of hydrostatic level, the fresh water aquifer is overrun by marine salt water, deteriorating drinking water supplies (Fig. 1).

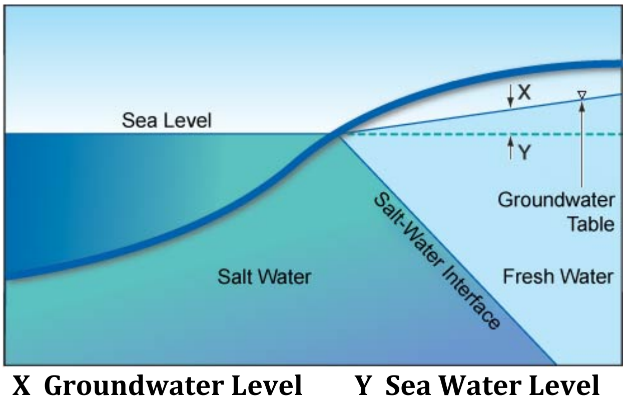

Fig. 1. Salt-water interface in an unconfined coastal aquifer according to the Ghyben-Herzberg relation. (after http://www.solinst.com)

Because these interferences have negative effects on costal economy, there have been produced some numerical models to estimate the quantity of fresh water that can be pumped into an aquifer without the intrusion of salt water. But this is not a very easy thing to do. Despite the estimations, there can be hard to settle an aquifer structure. Also, the distribution of salt water can be influenced by various factors: unknown faults and cavities that affect the salt water movement into an aquifer. In the same way, the presence of some undetected hydraulic properties particularities brings differences in salt water movement. Another factor is the change of water's hydraulic properties following the water movement. The blending of fresh and salt water usually has unsaturated calcium quantities (http://en.wikipedia.org/wiki/Saltwater_intrusion).

These phenomena happen in a long period of time and last till they react to the changes of pumped water quality, but also to changes of rainfall quantity. Together with factors variability and unpredictability, these phenomena make the whole ground situation sometimes a bit different from the previous estimations.

Some factors as World Ocean level variation, climatic variability and changes of groundwater recharge rate lead to uncertainties according to fresh water aquifer behavior around coastal areas.

The intrusion of salt water can be stopped by reducing fresh water extraction from aquifer or, if it's possible, by pumping fresh water back into the aquifer.

Salt water intrusion represents a danger for many inhabited coastal areas:

– The aquifer from Biscay Bay, Florida, that provides water supplies for Miami area, is settled into a calcareous and sandy region. It's been confirmed that the salt water advanced into the aquifer also following excessive channel dragging.

– The aquifer from Port Washington, Long Island area, New York, suffered a salt water intrusion in the '60, to a depth of 6 m that lead to the abandonment of some wells. Fresh water extraction slowed down in order not to aggravate more the problem; more recently, computerized models have been used on finding new extracting locations less vulnerable to salt water.

– Holland has a complex aquifer monitoring system because of its vast under sea level land. There are 3000 monitoring points and also a computerized model for tridimensional simulation of underground water movement. Monitoring is very important because fresh water aquifers are separated from the salt water aquifers only by a small clay layer.

– 30% of the drinking water that Los Angeles needs is extracted from wells. In the '20 there had been a salt water intrusion. From the years 1950, fresh water has been injected in aquifers from surface waters to reverse the progression of salt water. Even so, the intrusion continues in places where fresh water aquifers are exposed to salt water intrusion from deep ocean.

– In Israel, following intensive exploitation of fresh water aquifers faster than its regeneration rhythm, there appeared a salt water front that comes from Mediterranean Sea. So the serious is the problem that they started growing high salinity resistant crops, and the drinking water is obtained through desalinization process. Also, concrete injection in some ground locations had been used to form some underground dams to spot salt water advancement.

Where big rivers flow into the ocean appears substantial salinity modifications, depending on the water volume transported discharged into the ocean. An example is Amazon River, that has a discharge o 190000 m^3/s when he reaches the ocean, transforming near Ocean Atlantic area into a Mar Dolce (Fresh Sea) (P.Gâştescu, 2009).

2.3 Mechanical processes

Mechanical nature processes appear on streams, but more on coastal areas. Degradation and aggradation processes of river bed are part of the mechanical nature water hazards. Hydromorphological modifications are a result of erosion and accumulation processes that are more intense in flooding periods. Negative are bank degradation, degradation and even destruction of some hydrotechnical constructions (dams, dykes, breakwaters etc.). Very spectacular are the changing of river course for hundreds or even thousands of kilometers (Huang He River). Another negative effect of erosion is also the limitation of natural lands for crops and agricultural use.

Bank erosion doesn't affect too much river beds with bank hydromodifications. The main erosion rate for a river with no modifications in temperate region is of 10 m/year, and in tropical regions it reached even 200-400 m/year for Brahmaputra River (1975-1981). We should not forget that in the evaluation of bank erosion induced risk we have to take into account the frequency of this process.

A negative effect of river bed aggradation is floods frequency growth. The best example for such a phenomenon is Huang He River in China.

The most numerous risk phenomenona and processes happen in coastal areas, where is present a big part of world's towns (65 towns with over 2.5 mil. inhabitants) and the migration of peoples it's an enhancive phenomenon. For example, the population in U.S. coastal areas doubled between 1940 and 1980, and the population from the costs of the Atlantic Ocean and the Gulf of Mexico grew with 15% between 1945 and 1975. Now more than 60% of world's population lives in coastal areas, at less than 60 km from shore, and in 30 years it will reach 75%.

2.4 Environmental effects of water interferences

Whatever is nature of water interferences, they can influence the appearance and evolution of aquatic flora and fauna. So the thermal river pollution brings the modification of water temperature after using it as a cooling liquid in power plants and other industrial buildings. The main result is water heating, and some cases sudden water cooling, if the water comes from a reservoir or lake.

Water heating brings sudden decrease of the oxygen quantity from water and the derangement of river food chain. Some species can adapt more easily into warmer water, but other cannot, so there appears an unbalance in the environment. Underwater plants develop more easily into warm waters, but they have a shorter life and this leads of a growth of algas due to overpopulation. Very high water temperatures bring dysfunctions in the development of fish organisms (http://environmentengineering.blogspot.com).

Another thermal pollution phenomenon is the thermal shock that appears when power plants are started or stopped, affecting especially the fish populations near the evacuation mouths.

The increase of upwelling regions brings a growth of primary productivity levels and also of fishery production. Over 25% of world's fishery production comes from 5 upwelling areas that represent only 5 % of the total ocean area.

Chemical processes have a major impact on aquatic flora and fauna development. The most important effects are salt intrusions into continental area, but also into coastal areas (Fig. 2).

Various pollution sources have a strong environmental impact contributing at the growth of eutrophication and acidification processes of aquatic environment.

Surface and underground waters pollution affects the life of aquatic microorganisms, insects and birds, but also the health of terrestrial animals and plants. Also, pollution affects the water used in human activities. Depending on the pollution's nature and intensity, water exploitation can be diminished or even canceled for any purpose (physiologic, hygienic, industrial, recreational etc.).

Pollution has the worst effect on the health of various plants and animals that life in or near the water. Surface and underground water pollution has direct and indirect implications on human health. A large number of diseases can be propagated through direct contact with water environment (bath, wash, direct contact). As contagious disease we can remember conjunctivitis and ENT (ear, nose and throat) diseases that spread at water contact. Leptospirosis, tularemia and schistosomiasis can cause dermatological diseases. Water fat-soluble toxically components (such as halogenous compounds) can be absorbed through the skin. Other compounds, such as radon, can get in through water ingestion or vapor inhalation.

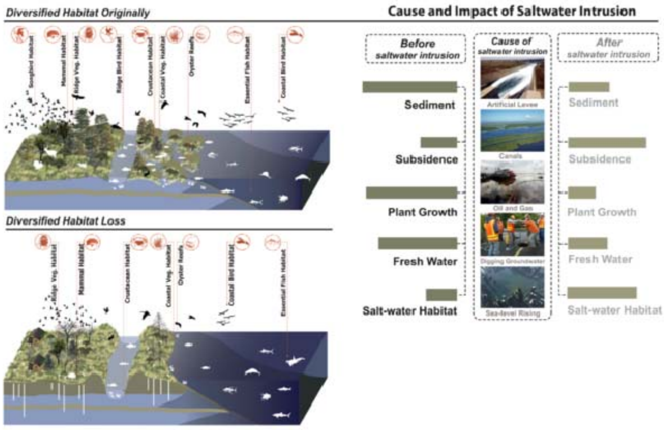

Fig. 2 Cause and impact of salt water intrusion (after http://www.en.wikipedia.org)

Surface water pollution can affect human body through ingestion, because the water is treated, but the water treating process cannot eliminate all chemical, parasitic and virus-like pollutants. So the WHO considers the presence in water of viruses as a health risk.

Some of the most frequent aquatic processes are eutrophication and acidification.

Eutrophication is a form of pollution of continental aquatic environments caused by an excessive natural or artificial growth of water nutrients, especially phosphorus and nitrogen. Unlike the natural process, artificial eutrophication is a fast process that determines successive and deep changes of aquatic environment condition. This brings environment degradation and affects the purpose of water utilization: water supplying, fish productivity, recreation etc.

Eutrophication affects all aquatic environments types: rivers, lakes, transient flows and coastal waters, and appears especially in stagnant and almost stagnant water environments.

Fresh water acidification is determined especially by acid rain. It has been noted for the first time in XVIIth century in England. The “acid rain” term was coined in 1872 by Robert Angus Smith. Only since the 1950’s has been observed that this is a cross-border problem. This process has been more researched only after it appeared in Central and Western Europe. In 1978 was launched the European Acidification Research and Monitoring Program (EMEP) and in USA a similar program appeared in 1980, which lead to global programs.

The main acidification cause is sulfur dioxide and nitrogen oxide released into the atmosphere. The natural sources have the same magnitude at global level with the anthropogenic ones, especially the burning of fossil fuels, but industrial ones have a worse effect than the natural ones. People released $80x10^6$ tons of sulfur oxides in 1975 and $90x10^6$ tons in 1985. Europe contributed with 44%, North America with 24%, Asia with 23%, Central and South America with 5.2%, Africa with 3% and Oceania with 1%. The sulfur dioxide emissions diminished in the developed countries after 1970, but the nitrogen oxide emissions still continued to grow.

Another source for acid rain is ground pollution with ammonium, nitrificated by bacteria, process that also produces hydrogen ions, causing acidification. Also, pyrite exposed to air and humidity action determines the release of hydrogen protons, causing a grave water acidification.

Soils and waters have the capacity to neutralize acidity through calcium and magnesium bicarbonates. But this is a limited capacity and it's lost after the bombarding with a high hydrogen, sulphate or azotate ions afflux. Lake's acidification is not caused by by the simple growth of air H^+ concentration, but by complete ground processes. This process does not appear in calcareous regions. This is the reason why it affects especially Northern America and Europe, where Quaternary Glaciation was more extended and the calcareous deposits are not as vast. Where there are no carbonates, aluminosilicates can neutralize acidification, but they are not so effective.

The decrease of soil pH determines the growth of toxically heavy metals. Some toxic metals can be mobilized and displaced in even stable combinations of soil. When the soil pH decreases below 6, some environment components may lose their food, leading to minerals deficiency. Also, soil pH reduction leads to oxygen reduction, to anaerobic bacteria growth, biodiversity reduction, filamentous algae and acidotolerant macrophytes development etc.

Last year's studies highlighted the acidification of marine waters. This is a warning on greenhouse gases (GHG) accumulation impact on atmosphere.

CO_2 is the main cause for global warming, but it also produces marine water acidification, causing the most important change of sea and ocean water in the last 20 mil. years, affecting marine food resources. It is well known that the water from oceans absorbs CO_2, as a part of the natural balancing mechanism. In fact, it absorbs a third of the world's CO_2 emissions, slowing the global warming. If this percent had still existed, the global warming would have been now at its height. The seas and oceans "sacrificed" themselves by protecting the planet. Human activities, especially, fossil fuels burning, induced a growth of till 392 parts per million of the CO_2 level, that was of approximate 280 parts per million at the beginning if the Industrial Revolution.

The acidification rhythm of the World Ocean in the XXth century grew with 0.1 pH unities, which amounts with a 30% growth of the hydrogen ions concentration [H^+]. Normally, the marine soil pH is slightly alkaline (8.3 after last researches), but the rate will reach 0.2-0.3 unities in the year 2100.

Unlike climatic changes - a complex and hard to measure process, ocean's acidification effects are easy to see and measure. The decrease of marine soil pH has a devastating effect on plankton and corals, with a calcium carbonate made skeleton. Even small pH modifications can change the balance of carbonate ions, making almost impossible building new marine skeletons and shells. The worst is that the modifications happen at a fast rate. The more acid marine water attacks the coral reefs, destroying entire marine habitats, affecting the capacity of forming new marine shells, destroying zooplankton and phytoplankton at the base of the food chain, threatening whole life forms in the world.

If the plankton disappeared, the effect on world's food supplies would be catastrophic, because it seats at the base of the food chain and all marine life depends on it. Even more, it has a direct contribution to CO_2 absorption and neutralization into atmosphere. Some data show some modifications of marine shells becoming slimmer and softer. Corals growth decreased with almost 30% and the soil pH modified too.

Ocean's acidification is an inevitable process determined by the growing atmospheric CO_2 concentrations. The negative impact of these emissions can be felt all over the world, in water and also terrestrial environments.

Mechanical processes, such as aggradation or degradation, influence especially the intensity of some environmental processes – the evolution of one component – substratum. The effects of mechanical and chemical processes are felt especially in coastal areas. As a result, now the mangroves from Asia and Africa are endangered, and those from Philippines have disappeared with 67% in 60 years (Romanescu and colab., 2009).

Conclusions

Water interferences represent a less approached hazard category in geography literature. The processes that follow these kinds of interferences may have physical, chemical, mechanical or environmental nature.

To identify the location and nature of water interference processes is a capital condition in the elaboration of water hazards prevention and reduction plans.

Water interferences are a distinctive hazard category, with very complex characteristics and multiple environment implications.

The environmental effects of these interferences can be felt in continental area, but mostly in coastal area.

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