WETLAND WATER BUDGETS IN THE MEKONG RIVER BASIN

A brief discussion of the hydrology of the Mekong River Basin (MRB) was given in the previous lesson. This lesson will provide more detail on the importance of wetland hydrology, one of the most significant components of aquatic ecosystems in the Basin.

The swamps, floodplains and coastal estuaries that are so prevalent in the MRB are transitional ecosystems between the terrestrial upland areas and open water aquatic ecosystems, like the Mekong River itself or Cambodia’s coastline. These wetland ecosystems are transitional in terms of spatial arrangement, for they are found between uplands and open water. However, they are also transitional in the amount of water they store and process. They represent the aquatic edge of many terrestrial plants, and the terrestrial edge of many aquatic plant species. Small changes in a wetland’s hydrology can result in significant biotic changes within the ecosystem. Hydrologic conditions can directly modify or change chemical and physical properties such as nutrient availability, soil salinity, sediment properties and pH. When hydrologic conditions in a wetland change even slightly, say for example to divert some water onto agricultural land, the biota may respond with massive changes in species composition and richness, or in ecosystem productivity.

To further understand the importance of wetland hydrology in the healthy functioning of the MRB, it is necessary to discuss the concept of the wetland water budget. The wetland hydroperiod is a result of the following factors: the balance between the inflows and outflows of water; the surface contours of the landscape; and the subsurface soil, geology and groundwater conditions. The first condition defines the wetland water budget (illustrated in Figure 1), and the second and third define the wetland’s capacity to store water. The general balance between water storage and inflows and outflows can be summarized with the following formula:

$$\Delta V/\Delta t = P_n + S_i + G_i - ET - S_o - G_o \pm T$$

where,

- V = the volume of water storage in the wetland (hectares/metre)
- $\Delta V/\Delta t$ = the change in volume of water storage in the wetland per unit time (h/m)
- P_n = net precipitation (mm)
- Net precipitation = total precipitation (P) – Interception (I)
- S_i = surface inflows, including flooding streams (m^3 per storm event or unit time)
- G_i = groundwater inflows (volume or volume per unit time)
- ET = evapotranspiration (mm per unit time)
- S_o = surface outflows (m^3 per storm event or unit time)
- G_o = groundwater outflows (volume or volume per unit time)
- T = tidal inflow (+) or outflow (–) (volume or volume per unit time)

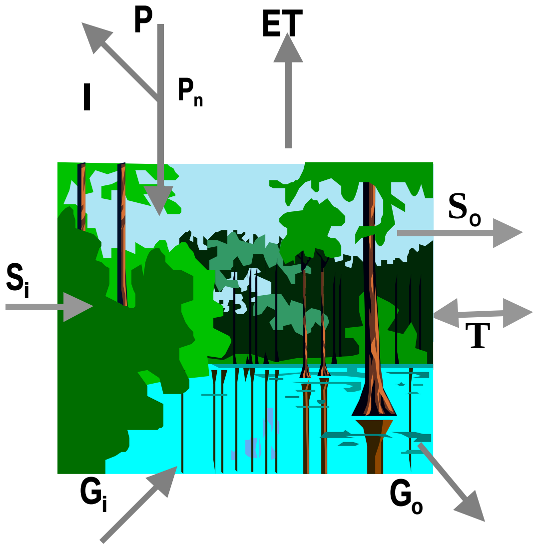

Figure 1 The wetland water budget: influences on the change in water storage per unit time

GROUNDWATER

No discussion of the movement of water through the wetlands of the MRB would be complete without a mention of groundwater. Groundwater is just that; water under ground that we cannot see. Groundwater is extremely plentiful in the Basin, and on Earth. It is estimated that nearly 22% of the water found on the planet is stored underground in the form of groundwater. Roughly 97% of the freshwater potentially available for human use is groundwater; the remainder is stored in rivers, lakes and swamps (UNEP, 1996).

Groundwater reserves are primarily recharged by rain that infiltrates through the soil into the underlying substrate. Wetlands and shallow aquatic habitats can also contribute to groundwater recharge through percolation of water. Once the water is underground, flow rates can range from more than 10 m per day to as little as

Groundwater Pollution

Nearly one third of Asia's population depends on groundwater as a water source. Even with the abundance of surface water within the MRB, groundwater is relied upon because it is cheap to recover and requires little treatment. What happens, though, when a groundwater aquifer becomes polluted?

Agricultural activities, urbanization and industrial activity are potential causes of groundwater pollution in the MRB. And once polluted, groundwater is extremely difficult to purify, due to its huge volume, relative inaccessibility and slow flow rates.

The risk of groundwater pollution depends upon the vulnerability of the aquifer to pollution and the loading of potential pollutants to which it may be subjected. Pollutants could include fertilizers and pesticides, industrial chemicals, or raw sewage. Vulnerability depends in part upon the extent to which pollutant concentrations are reduced between the land surface and the water table, and on the rate at which remaining pollutants travel down through the aquifer.

Protection of groundwater supplies involves identification of pollutant sources, such as industrial plants, landfills or wastewater discharge sites. Efforts should be made to reduce pollution from these sources through improved waste disposal practices and stricter land use planning regulations. Some pollutant sources are not as easily identified and controlled, such as areas of intensive agriculture. With such a diffuse pollutant source, restrictions may have to be placed on the amount and type of chemicals sold in order to protect groundwater aquifers.

1 m per year, eventually reaching an outlet.

The water-bearing material within the earth's subsurface is called an aquifer. This material can be gravel or consolidated material such as bedrock or sandstone. Sands can store nearly 30% of their volume as water; rock can store water in pore spaces or in tiny fractures. Aquifers are usually bounded above by the saturated zone, which contains both air and water, and below by a dry, impermeable layer of clay or rock. The boundary between the saturated zone and the unsaturated zone is termed the water table. In drier regions of the world, the water table can be as much as 100 m below the earth's surface; in the low-lying, moist regions of the MRB, the water table can be at or only just below the soil surface.

WETLAND FUNCTIONS

The wetland ecosystems of the MRB play vital roles in both protection and enhancement of biodiversity within the region, while preserving and cleansing the water supply for local residents. When wetlands are drained and filled, the valuable functions that they perform must be replaced at the expense of local villagers, governments, or international funding organizations. Some functions of wetland ecosystems in the MRB are described below.

Flood Mitigation

Wetlands intercept and store stormwater, thereby changing sharp run-off peaks (potential flooding) to slower discharges over longer periods of time. Because it is usually the peak flows that produce flood damage, the effect of the wetland area is to reduce the danger of flooding. Riverine wetlands like those so plentiful within the MRB are particularly valuable in their flood reducing functions. Coastal wetlands function similarly to protect low-lying villages and cities; they can absorb the first fury of ocean storms as the storms come ashore. When freshwater and coastal wetland ecosystems are filled or degraded, society must bear the cost of stormwater retention basins and coastal breakwaters, or must suffer the damages caused by flood and storm action.

Aquifer Recharge

Some wetlands function to recharge the underlying groundwater. In general, groundwater recharge tends to occur around the edges of wetlands and is thought to be related to the edge:volume ratio of the wetland. The rate of infiltration is relative to the surface area of the wetland and the depth to the underlying water table.

Water Quality

Wetlands have been shown to remove organic and inorganic nutrients and toxic materials from the water that flows across them. In fact, artificial wetlands are being designed and constructed specifically for this purpose. Substances such as agricultural pesticides and fertilizers and human or animal wastes can settle out or be absorbed into wetland soils and plant biomass. Wetlands can aid in pollutant removal in these ways:

- Reducing flow velocity as water enters a wetland, causing sediments and chemicals sorbed to sediments to drop out of the water column
- Enabling denitrification, chemical precipitation, and other chemical reactions that remove certain chemicals from water through the

action of various aerobic and anaerobic processes

- High productivity in many tropical wetlands enables high rates of mineral and chemical uptake by vegetation and subsequent burial in sediments when the plants die
- A diversity of decomposers aid decomposition processes in wetland sediments
- The accumulation of large amounts of organic matter, which causes the permanent burial of chemicals
- A high degree of contact of water flowing into the wetland with sediments because of the shallow depth of many wetlands, leading to significant sediment-water exchange.

NUTRIENT CYCLING IN THE MEKONG RIVER DELTA

Nutrients are carried into wetlands by hydrologic inputs of precipitation, river flooding, tides, and surface and groundwater inflows. Nutrient outflow is controlled primarily by the outflow of waters. Wetland hydrologic and nutrient flows greatly influence productivity and decomposition within the wetland ecosystem. It is the ‘openness’ of a wetland system to changes in water levels and volumes that encourage high rates of primary productivity. Wetlands that tend to remain stagnant or permanently flooded, with little to no inflow and outflow of water, generally have fairly low productivities. Wetlands that are periodically flooded by rivers, like those in the Mekong Delta, or tidal influence tend to be very productive ecosystems. Productivity is generally lowest in a permanently flooded wetland where nutrients are brought into the system only through rainfall. The vast floodplains of the Mekong Delta have tremendous productivity, as large amounts of nutrients pass through these wetlands during flooding of the river. Freshwater tidal wetlands may be the most productive of all in the region, as they receive the nutrients from both the river and tidal inflows, while avoiding the stress of saline soils.

A wetland’s ecosystem mass balance represents a quantitative description of the inputs, outputs and internal cycling of nutrients and chemicals. The mass balance of several elements essential to life, such as nitrogen, carbon, and phosphorous, can be termed the wetland’s nutrient budget.

Knowledge of the mass balance concept is important for understanding the fate of an agricultural chemical or any other potentially toxic substance applied to the land or the water. When nutrients and chemicals cycle through the wetlands, they are exchanged between various pools, or standing stocks, of nutrients and chemicals within the wetland. This cycling includes processes such as litter production, decomposition, and the transformation of nutrients into biologically available forms.

When a potentially harmful chemical is applied to the land, a portion of it may percolate down through the soil or run off the site during a storm event. Regardless of where that chemical was applied, intact wetlands have the capacity to take up and store various quantities of the substance prior to its release into a river or a coastal estuary. The wetland can function as a sink for the chemical, which means that it maintains a net retention of the substance. For example, plants take up nutrients and chemicals through a process called translocation. A chemical in the soil substrate is taken up by the plant roots, then travels through the stems and into the leaves. The concentration of the chemical in the receiving environment is effectively reduced, provided the vegetation is not harvested. Chemicals can also be stored, or sequestered, in the wetland sediments, rendering them potentially unavailable to other biological cycling as long as the soils remain saturated and anaerobic.

The wetland could also be a transformer, wherein a potentially harmful substance is rendered harmless through various biological processes. The wetlands of the Mekong River Basin are essentially the filters for the region. They have a substantial capacity to assimilate and store the wastes resulting from human use and disturbance of the land. However, their treatment capacity is not limitless, and indiscriminate removal of wetland ecosystems will further decrease their filtering functions.