

Report

on

Preliminary Investigation

of Environment Baseline

on

Hydropower Development of

Ayeyarwady River above Myitkyina,

Myanmar

Glossary of Environmental Terms

Abatement

Reducing the degree or intensity of, or eliminating, pollution.

Abiotic

Non-Living.

Absorption

The passage of one substance into or through another; an operation in which one or more soluble components of a gas mixture are dissolved in a liquid.

Accident site

The location of and unexpected occurrence, failure, or loss, either at a plant or along a transportation route, resulting in a release of hazardous materials.

Acid deposition

A complex chemical and atmospheric phenomenon that occurs when emissions of sulfur and nitrogen compounds and other substances are transformed by chemical processes in the atmosphere, often far from the original sources, and then deposited on earth in either a wet or a dry form. The wet forms, popularly called " acid rain", can fall as rain, snow or fog. The dry forms are acidic gases or particulates.

Acute toxicity

The ability of a substance to cause poisonous effects resulting in severe biological harm or death soon after a single exposure or dose; also, any severe poisonous effect resulting from a single short-term exposure to a toxic substance. See also Chronic toxicity; Toxicity.

Aerobic

Life or process that require, or are not destroyed by, the presence of oxygen. See also anaerobic.

Agricultural Pollution

A liquid and solid wastes from farming, including runoff and leaching of pesticides and fertilizers; erosion and dust from plowing; animal manure and carcasses; and crop residues and debris.

Air Pollution

The presence of contaminant or pollutant substances in the air that do not disperse properly and interfere with human health or welfare or produce other harmful environmental effects.

Ambient Air

Any unconfined portion of the atmosphere; open air, surrounding air.

Aquifer

An underground geological formation, or group of formations, containing usable amounts of groundwater that can supply wells and springs.

Atmosphere (as a measurement)

A standard unit of pressure representing the pressure exerted by a 29.92 inch column of mercury at sea level at 45 degree latitude and equal to 1000 grams per square centimeter.

Bacteria (singular bacterium)

Microscopic living organism that can aid in pollution control by consuming or breaking down organic matter in sewage or by similarly acting on oil spills or other water pollutants. Bacteria in soil, water, or air can cause human, animal and plant health problems.

Benthic Organism (benthos)

A form of aquatic plant or animal life found on or near the bottom of a stream, lake, or ocean.

Biochemical Oxygen Demand (BOD)

A measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.

Biodiversity Hot Spots

Areas with exceptionally high numbers of endemic species.

Biological Oxidation

The way bacteria and microorganism feed on and decompose complex organic materials; used in self-purification of water bodies and in activated sludge wastewater treatment.

Biological Treatment

A treatment technology the uses bacteria to consume waste and thus break down organic materials.

BOD₅

The amount of dissolved oxygen consumed in five days by biological process breaking down organic matter.

Cadmium (Cd)

A heavy metal element that accumulates in the environment.

Carbondioxide (CO₂)

A colourless, odorless, nonpoisonous gas that results from fossil fuel combustion and is normally apart of the ambient air.

Carbonmonoxide (CO)

A colourless, odorless, poisonous gas produced by incomplete fossil fuel combustion.

Carcinogen

Any substance that can cause or contribute to the production of cancer.

Chemical oxygen demand (COD)

A measure of the oxygen require to oxidize all compounds in water, both organic and inorganic.

Chlorofluorocarbons (CFCs)

A family of inert, nontoxic and easily liquefied chemicals used in refrigeration air conditioning, packaging, and insulation or as solvents and aerosol propellants. Because CFCs are not destroyed in the lower atmosphere, they drift into the upper atmosphere, where their chlorine components destroyed ozone.

Chromium See heavy metals

Chronic toxicity

The capacity of a substance to cause long term poisonous human health effects. See also Acute toxicity.

Climate

A description of the long-term pattern of weather in a particular area.

Coagulation

A clumping of particles in waste water to settle out impurities; often induced by chemicals such as lime, alum and iron salts.

Compound

A molecule made up of two or more kinds of atoms held together by chemical bonds.

Compensation measures

Alternative resources (land, property or money) provided to displaced people or others adversely affected by a project as mitigation for losses suffered.

Contaminant

Any physical, chemical, biological, radiological substance or matter that has an adverse affect on air, water, or soil.

Corrosion

The dissolving and wearing away of metal caused by a chemical reaction the occurs between water and the pipes that the water contracts, or when chemicals touching a metal surface, or when two metals are in contact.

Cultural heritage

The cultural practices and resources of current populations (religions; languages; ideas; social; political and economic organizations) and their material expressions in the forms of sacred elements of natural sites or artifacts and building; landscaper resulting from cultural practices over historical and prehistoric times; and archaeological resources; including artifacts, plant and animal remains associated with human activities, burial sites and architect rural elements.

Decomposition

The breakdown of matter by bacteria and fungi; changes the chemical makeup and physical appearance of materials.

Degradation

The process by which a chemical reduced to a less complex form.

Delta

Fan-shaped sediment deposit found at the mouth of a river.

Discharge

The amount of water that passes a fixed point in a given amount of time, usually expressed as liters or cubic feet of water per second.

Decommissioning

Removing a dam from service and, where appropriate, physically dismantling it.

Dissolved solids

Disintegrated organic and inorganic material contained in water. Excessive amounts make water unfit for drinking or for use in industrial processes.

Ecofeminism

A pluralistic, nonhierarchical, relationship-oriented philosophy that suggests how humans could reconceived themselves and their relationships to nature in nondominating ways as an alternative to patriarchal systems of domination.

Ecosystem

The interacting system of a biological community and its nonliving environmental surroundings.

Effluent

Wastewater treated or untreated that flows out of a treatment plant, sewer, or industrial outfall; generally refers to wastes discharged into surface waters.

Emission

Pollution discharged into the atmosphere from smokestacks, other vents, and surface areas of commercial or industrial facilities, from residential chimneys; and from motor vehicle, locomotive, or aircraft exhausts.

Emission factor

The relationship between the amount of pollution produced and the amount of raw material processed. For example, an emission factor for a blast furnace making iron would be the number of pounds of particulates per ton of raw material.

Emission standard

The maximum amount of air polluting discharge legally allowed from a single source, mobile or stationary.

Environmental flow

The specific release of water from a dam to ensure the maintenance of downstream aquatic ecosystems and key species. The flows may include seasonal or annual flows and/or regular or irregular pulses to meet ecosystem needs. They may also be linked to livelihood needs of downstream affected people.

Estuary

A bay or drowned valley where a river empties into the sea.

Eutrophication

The slow aging process during which a lake, estuary, or bay evolves into a bog or marsh and eventually disappears. During the later stages of eutrophication the water body is choked by abundant plant life as the results of increased amounts of nutritive compounds such as nitrogen and phosphorus. Human activities can accelerate the process.

Evapotranspiration

The loss of water from the soil both by evaporation and by transpiration from the plants growing in the soil.

Exposure

A potential health threat to the living organisms in the environment due to the amount of radiation or pollutant present in the environment.

Famines

Acute food shortages characterized by large-scale loss of life, social disruption, and economic chaos.

Fertilizer

Materials such as nitrogen and phosphorus that provide nutrients for plants. Commercially sold fertilizers may contain other chemicals or may be in the form of processed sewage sludge.

Flood management

A broad concept that focuses on reducing flood hazards through a combination of policy, institutional, regulatory and project measures (such as replanting catchment areas), while recognizing that they can never be fully controlled. This takes into account the beneficial uses of natural floods, which are more difficult to quantify in human and economic terms but which sustain natural systems that also have economic, social, cultural and ecosystem values and functions.

Fluorocarbon (FCs)

Any of a number of organic compounds analogous to hydrocarbons in which one or more hydrogen atoms are replaced by fluorine. Once used in the United States as a propellant in aerosols, they are now primarily used in coolants and some industrial processes. FCs containing chlorine are called chlorofluorocarbons (CFCs). They are believed to be modifying the ozone layer in the stratosphere, thereby allowing more harmful solar radiation to reach the Earth's surface.

Fly ash

Noncombustible residual particles from the combustion process carried by flue gas.

Fossil Fuels

Petroleum, natural gas, and coal created by geological forces from organic wastes and dead bodies of formerly living biological organisms.

Fresh Water

Water other than seawater, covers only about 2 percent of earth's surface, including streams, rivers, lakes, ponds, and water associated with several kinds of wetlands.

Fuelwood

Branches, twigs, logs, wood chips, and other wood products harvested for use as fuel.

Greenhouse effect

The warming of the Earth's atmosphere caused by a buildup of carbon dioxide or other trace gases; many scientists believe that this buildup allows light from the sun's rays to heat the Earth but prevents a counterbalancing loss of heat.

Green Plans

Integrated national environmental plans for reducing pollution and resource consumption while achieving sustainable development and environmental restoration.

Groundwater

The supply of fresh water found beneath the Earth's surface (usually in aquifers), which is often used for supplying wells and springs. Because groundwater is a major source of drinking water leaching agricultural or industrial pollutants or substances from leaking underground storage tanks are contaminating it.

Heavy metals

Metallic elements with atomic number greater than 20, such as mercury and lead. They can damage living things at low concentrations and tend to accumulate in the food chain.

Hydrocarbons (HC)

Chemical compounds that consist entirely of carbon and hydrogen.

Hydrogen sulfide (HS)

Gas emitted during organic decomposition and as a by-product of oil refining and burning. It smells like rotten eggs and, in heavy concentration, can cause illness.

Impoundment

A body of water or sludge confined by a dam, dike, floodgate, or other barrier.

Indirect discharge

Introduction of pollutants from a non-domestic source into a publicly owned waste treatment system. Indirect dischargers can be commercial or industrial facilities whose wastes go into the local sewers.

Infiltration

The penetration of water through the ground surface into subsurface soil or the penetration of water from the soil into sewer or other pipes through defective joints, connections, or manhole walls. 2. A land application technique whereby large volumes of wastewater are applied to land and allowed to penetrate the surface and percolate through the underlying soil. See also Percolation.

Inorganic chemicals

Chemical substances of mineral origin, not of basically carbon structure.

Insecticide

A pesticide compound specifically used to kill or control the growth of insects.

Irrigation

Technique for applying water or wastewater to land areas to supply the water and nutrient needs of plants.

Large dam

A dam with a height of 15m or between 5-15m high and have a reservoir volume of more than 3 million m³, they are also classified as large by the International Commission on Large Dams. In this report everything else is considered a small dam.

Leaching

The process by which soluble constituents are dissolved and carried down through the soil by a percolating fluid. Leaching may occur in farming areas, feedlots, and landfills and may result in hazardous substances entering surface water, groundwater, or soil. See also Leachate.

Main-stem

The main course of a river, characterized by its middle and lower reaches.

Marine

Living in or pertaining to the sea.

Marsh

Wetland without trees; in North America, this type of land is characterized by cattails and rushes.

Methane

A colorless, nonpoisonous, flammable gas created by anaerobic decomposition of organic compounds.

Microbes

Microscopic organisms such as algae, viruses, bacteria, fungi, and protozoa, some of which cause disease.

Monitoring

Periodic or continuous surveillance or testing to determine the level of compliance with statutory requirements or pollutant levels in various media or in humans, animals, and other living things.

Monsoon

A seasonal reversal of wind patterns caused by the different heating and cooling rates of the oceans and continents.

Natural resources

Goods and services supplied by the environment.

Nitrate

A compound containing nitrogen that can exist in the atmosphere or as a dissolved gas in water and can have harmful effects on humans and animals. Nitrates in water can cause severe illness in infants and cows.

Nitric oxide (NO)

A gas formed by combustion under high temperature and high pressure in an internal combustion engine. It changes to nitrogen dioxide in the ambient air and contributes to photochemical smog.

Nitrogen dioxide (NO₂)

The result of nitric oxide combining with oxygen in the atmosphere; a major component of photochemical smog.

Nitrogenous wastes

Animal or vegetable residues that contain significant amounts of nitrogen.

Nonpoint sources

Pollution sources that are diffuse and do not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm-water runoff. The commonly used categories for non-point sources are agriculture, forestry, urban, mining, construction, dams and channels, land disposal, and saltwater intrusion.

Nutrient

Any substance assimilated by living things that promotes growth. The term is generally applied to nitrogen and phosphorus in wastewater but is also applied to other essential and trace elements.

Optimum

The most favorable condition in regard to an environmental factor.

Organic

Referring to or derived from living organisms. 2 .In chemistry, any compound containing carbon.

Organic chemicals/compound

Animal - or plant-produced substances containing mainly carbon, hydrogen, and oxygen.

Organophosphates

Pesticide chemicals that contain phosphorus; used to control insects. They are short-lived, but some can be toxic when first applied.

Overharvesting

Harvesting so much of a resource that it threatens its existence.

Oxidation

1. The addition of oxygen, which breaks down organic waste or chemicals such as cyanides, phenols, and organic sulfur compounds in sewage by bacterial and chemical means.
2. Oxygen combining with other elements. 3 . The process in chemistry whereby electrons are removed from a molecule.

Ozone (O₃)

Found in two layers of the atmosphere, the troposphere and the stratosphere. In the troposphere (the layer extending 7 to 10 miles up from the Earth's surface), ozone is a chemical oxidant and major component of photochemical smog. In the stratosphere (the atmospheric layer beginning 7 to 10 miles above the Earth's surface), ozone is a form of oxygen found naturally that provides a protective layer shielding the Earth from the harmful health effects of ultraviolet radiation on humans and the environment.

Ozone depletion

Destruction of the stratospheric ozone layer that shields the Earth from ultraviolet radiation harmful to biological life. This destruction of ozone is caused by the breakdown of certain chlorine-or bromine-containing compounds (chlorofluorocarbons or halons) that break down when they reach the stratosphere and catalytically destroy ozone molecules.

Particulates

Fine liquid or solid particles, such as dust, smoke, mist, fumes, or smog, found in air or emissions.

Permeability

The rate at which liquids pass through soil or other materials in a specified direction.

Pesticide

Substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any pest. Also, any substance or mixture of substances intended for use as a plant regulator, defoliant, or desiccant. Pesticides can accumulate in the food chain or contaminate the environment if misused.

Phenols

Organic compounds that are by-products of petroleum refining, tanning, and textile, dye, and resin manufacturing. Low concentration cause taste and odor problems in water; higher concentrations can kill aquatic life and humans.

Phosphates

Certain chemical compounds containing phosphorus.

Phosphorus

An essential chemical food element that can continue to the eutrophication of lakes and other water bodies. Increased phosphorus levels result from discharge of phosphorus containing materials into surface waters.

Photosynthesis

The manufacture of carbohydrates and oxygen by plants from carbon dioxide and water in the presence of chlorophyll, using sunlight as an energy source.

Phytoplankton

That portion of the plankton community comprised of tiny plants, e.g., algae, diatoms.

Point source

A stationary location or fixed facility from which pollutants are discharged or emitted; any single identifiable source of pollution, e.g., a pipe, ditch, ship, ore pit, or factory smokestack.

Policy

A societal plan or statement of intentions intended to accomplish some social good.

Pollution

To make foul, unclean, dirty; any physical, chemical, or biological change that adversely affects the health, survival, or activities of living organisms or that alters the environment in undesirable ways.

Potable water

Water that is safe for drinking and cooking.

ppm/ppb

Parts per million/parts per billion, a way of expressing tiny concentrations of pollutants in air, water, soil, human tissue, and food and or other products.

Precipitation

Removal of solids from liquid waste so that the hazardous solid portion can be disposed of safely; removal of particles from airborne emissions.

Prevention

Measures taken to minimize the release of wastes to the environment.

Primary waste water treatment

First steps in wastewater treatment; screens and sedimentation tanks are used to remove most materials that float or will settle. Primary treatment results in the removal of about 30% of carbonaceous biochemical oxygen demand (BOD) from domestic sewage. See also secondary wastewater treatment; tertiary wastewater treatment.

Rainforest

A forest with high humidity, constant temperature, and abundant rainfall (generally over 380 cm [150 in] per year); can be tropical or temperate.

Raw sewage Untreated wastewater.

Reclamation

Chemical, biological, or physical clean-up and reconstruction of severely contaminated or degraded sites to return them to something like their original topography and vegetation.

Residual

Amount of a pollutant remaining in the environment after a natural or technological process has taken place, e.g., the sludge remaining after initial wastewater treatment, or particulates remaining in air after the air passes through a scrubbing or other pollutant removal process.

Resource

In economic terms, anything with potential use in creating wealth or giving satisfaction.

Riparian

Lying on or adjacent to a river or lake. Used to denote people, plants or wildlife living along the water's edge.

Runoff

That part of precipitation, snowmelt, or irrigation water that runs off the land into streams or other surface water; can carry pollutants from the air and land into the receiving waters.

Salinity

Amount of dissolved salts (especially) sodium chloride) in a given volume of water.

Sedimentation

Letting solids settle out of waste water by gravity during wastewater treatment.

Sewage

The waste and wastewater produced by residential and commercial establishments and discharged into sewers.

Sewage sludge

Sludge produced at a municipal treatment works.

Silt

Fine particles of sand or rock that can be picked up by the air or water and deposited as sediment.

Sludge

A semisolid residue from any of a number of air or water treatment processes. Sludge can be hazardous waste.

Smog

Fog made heavier and darker by smoke. Air pollution associated with oxidants. See also Photochemical oxidants.

Smoke

Particles suspended in air after incomplete combustion of materials.

Soil

A complex mixture of weathered mineral materials from rocks, partially decomposed organic molecules, and a host of living organisms.

Solid wastes

Nonliquid, nonsoluble materials, ranging from municipal garbage to industrial wastes, that contain complex, and sometimes hazardous, substances. Solid wastes include sewage sludge, agricultural refuse, demolition wastes, and mining residues. Technically, solid wastes also refer to liquids and gases in containers.

Stack

A chimney or smokestack; a vertical pipe that discharges used air.

Sulfur dioxide (SO₂)

A heavy, pungent, colorless, gaseous air pollutant formed primarily by processes involving fossil fuel combustion.

Sustainable development

A real increase in well being and standard of life for the average person that can be maintained over the long-term without degrading the environment or compromising the ability of future generations to meet their own needs.

Surface water

All water naturally open to the atmosphere (rivers, lakes, reservoirs, streams, impoundments, seas, estuaries, etc.); also refers to springs, wells, or other collectors that are directly influenced by surface water.

Suspended solids

Small particles of solid pollutants that float on the surface of or are suspended in sewage or other liquids. They resist removal by conventional means. See also Total suspended solids.

Swamp

Wetland with trees, such as the extensive swamp forests of the southern United States.

Terracing

shaping the land to create level shelves of earth to hold water and soil; requires extensive hand labor or expensive machinery, but it enables farmer to farm very steep hillsides.

Thermal pollution

Discharge of heated water from industrial processes that can affect the life processes of aquatic organisms.

Total suspended solids (TSS)

A measure of the suspended solids in wastewater, effluent, or water bodies. See also Suspended solids

Toxic pollutants

Materials contaminating the environment that cause death, disease, or birth defects in organisms that ingest or absorb them. The quantities and length of exposure necessary to cause these effects can vary widely.

Toxic substance

A chemical or mixture that may present an unreasonable risk of injury to health or the environment.

Toxicity

The degree of danger posed by a substance to animal or plant life. See also Acute toxicity; Chronic toxicity

Urban runoff

Storm water from city streets and adjacent domestic or commercial properties that may carry pollutants of various kinds into sewer systems or receiving waters.

Vector

1. An organism, often an insect or rodent, that carries disease.
2. An object (e.g. plasmids, viruses, or other bacteria) used to transport genes into a host cell. A gene is placed in the vector; the vector then "infects" the bacterium.

Wastes

1. Unwanted materials left over from a manufacturing process.
2. Refuse from places of human or animal habitation.

Wastewater treatment plant

A facility containing a series of tanks, screens, filters, and other processes by which pollutants are removed from water.

Wastewater

Spent or used water from individual homes, communities, farms, or industries that contains dissolved or suspended matter.

Water pollution

The presence in water of enough harmful or objectionable material to damage water quality.

Water quality criteria

Specific levels of water quality that, if reached, are expected to render a body of water suitable for its designated use. The criteria are based on specific levels of pollutants that would make the water harmful if used for drinking, swimming, farming, fish production, or industrial processes.

Water table

The top layer of the zone of saturation; undulates according to the surface topography and subsurface structure.

Wilderness

An area of undeveloped land affected primarily by the forces of nature; an area where humans are visitors who do not remain.

Wildlife

Plants, animals and microbes that live independently of humans; plants, animals, and microbes that are not domesticated.

Woodland

A forest where tree crowns cover less than 20 percent of the ground; also called open canopy.

1. INTRODUCTION

The development of seven hydropower stations in Nmai Hka and Mali Hka of Ayeyarwady is a mega project in Myanmar planned to meet the future needs of the national economy. The purpose is to generate hydropower, to control flood and to improve navigation. The hydropower dams will have total installed capacity of 16500 MW and total annual power production will be 90.85 billion kWh. The two rivers are of high conservation importance. Height of the dams ranges from 100 meter to over 200 meter having storage capacity of 321 to 12400 million m³ respectively. Most of the dams fall in the high dam category according to WCD standard. Feasibility studies were undertaken by China Power Investment Corporation. This assessment is aimed to avoid reckless exploitation of renewable power potentials as required by Myanmar Government. Biodiversity And Nature Conservation Association (BANCA) was assigned for the EIA study of the project.

2. OBJECTIVES

The study aims to collect baseline data of water, atmospheric, acoustic environment, point and non point pollution sources of the project area at present.

The basic data will anticipate and appraise impacts of this hydropower development. Follow up monitoring will give results as to whether there are significant changes compared to these baseline data which make necessary rectification possible.

Most of the investigation sites are at the proposed hydropower station sites but some are at specific river stations. The environmental baseline study is to fulfill part of the EIA requirements.

3. SCOPE OF WORK

In cooperation and in accordance with the BANCA group, survey teams performed the preliminary assessment of the water quality survey at low flow and high flow of the said river systems at selected river stations once in summer and another in rainy season of 2009.

The proposed project areas have a complex river ecosystem situated at the apex of the mighty Ayeyarwady river of Myanmar.

To carry out the works efficiently and comprehensively, BANCA established one survey team including soil and water scientists and engineers under the leadership of an experienced and qualified person.

An independent group of experts verified and analysed the collected data to study the present situation of environmental quality of the water, air and sound in the project area. This type of baseline survey is a prerequisite work. By implementing the project in Myanmar it is required to compare the pre-project baseline data with the post-project monitoring results. The purpose is to assess the changes and impacts caused by natural and man-made interventions in the natural river basins and to observe its ecosystem in both upstream and downstream of the Ayeyarwady river. As part of Environmental Impact Assessment, special investigation of the present surface water quality survey was made in the area above Myitkyina where hydropower development of Ayeyarwady River Basin has yet to be implemented. The investigations were done at low flow period starting from January to March in 2009 and at high flow period starting from June to August in 2009. Periodic monitoring of the same river station should be done

successively before and after the implementation of the projects to get comprehensive results. But the survey team was able to assess the water quality of the said rivers within the limited time of one year in 2009 and analyze these data efficiently.

The team carried out the monitoring of surface water qualities at low flow and high flow consisting pH, water temperature, total suspended solids, BOD, COD, nitrogen, phosphorus, phenol, cyanide, oil and grease, arsenic, chromium, mercury and zinc in 18 river stations of proposed dam sites and the key tributaries of the river system.

The survey team's effort of monitoring the present water quality where hydropower projects are yet to be formulated in the uppermost part of Ayeyarwady river is a giant step forward for the future monitoring along the course of the Ayeyarwady inside Myanmar and up to the rice bowl of Ayeyarwady Delta.

3.1. Hydrology

3.1.1. Climate

Climate classification of the project area is made based on the rainfall and temperature data of the two meteorological stations, Myitkyina and Putao.

The warmest month of Myitkyina is August. It has a mean temperature 28.2°C. That of Putao is also August and it has the same temperature 28.2°C. The warmest month of both stations has a mean temperature above 10°C.

The coldest month of Myitkyina is January. It has a mean temperature 18.2°C. That of Putao is also January and it has a mean temperature 13.9°C. It can be said that the temperature of the coldest month of the area is between 18°C and 0°C.

According to this temperature basis, the area is in the main climatic group C, **humid mesothermal**.

For verifying the climatic subgroup, the temperature of the warmest month is the basic. That of both stations is over 22°C. The area is in the subgroup Ca, **humid subtropical, hot summers**.

The rainfall of Myitkyina in the wettest summer month, June, is 536 mm. The rainfall in the driest winter month, December, is 5 mm. At Putao, the rainfall in the summer month, July, is 1202 mm. That in the driest winter month, December, is 6 mm. It can be seen that the wettest rain is much more than 10 times the driest rain. The area is in the climatic subgroup Caw, **dry winters**.

The climatic group of the area is Caw, humid mesothermal, humid subtropical, hot summers and dry winters.

(Ref. Tropical Soil Manual, The Koppen Climate Classification, P. 381)

3.1.2. Rainfall and Runoff

The normal rainfall of the five stations in the project are as follows.

Table. 1

Station	Annual rainfall	
	(inches)	(mm)
1. Putao	156.84	3984
2. Sumprabum	136.67	3471
3. Myitkyina	84.41	2144
4. Htawgaw	82.98	2108
5. Sadon	119.70	3040

The catchment area rainfall is computed to be 3352 mm, based on the above data. Then, the annual runoff is estimated as 114000 million cubic meters. The estimate of CISPDR, CWRC is 144500 million cubic meters, which is 127 percent of the present estimate.

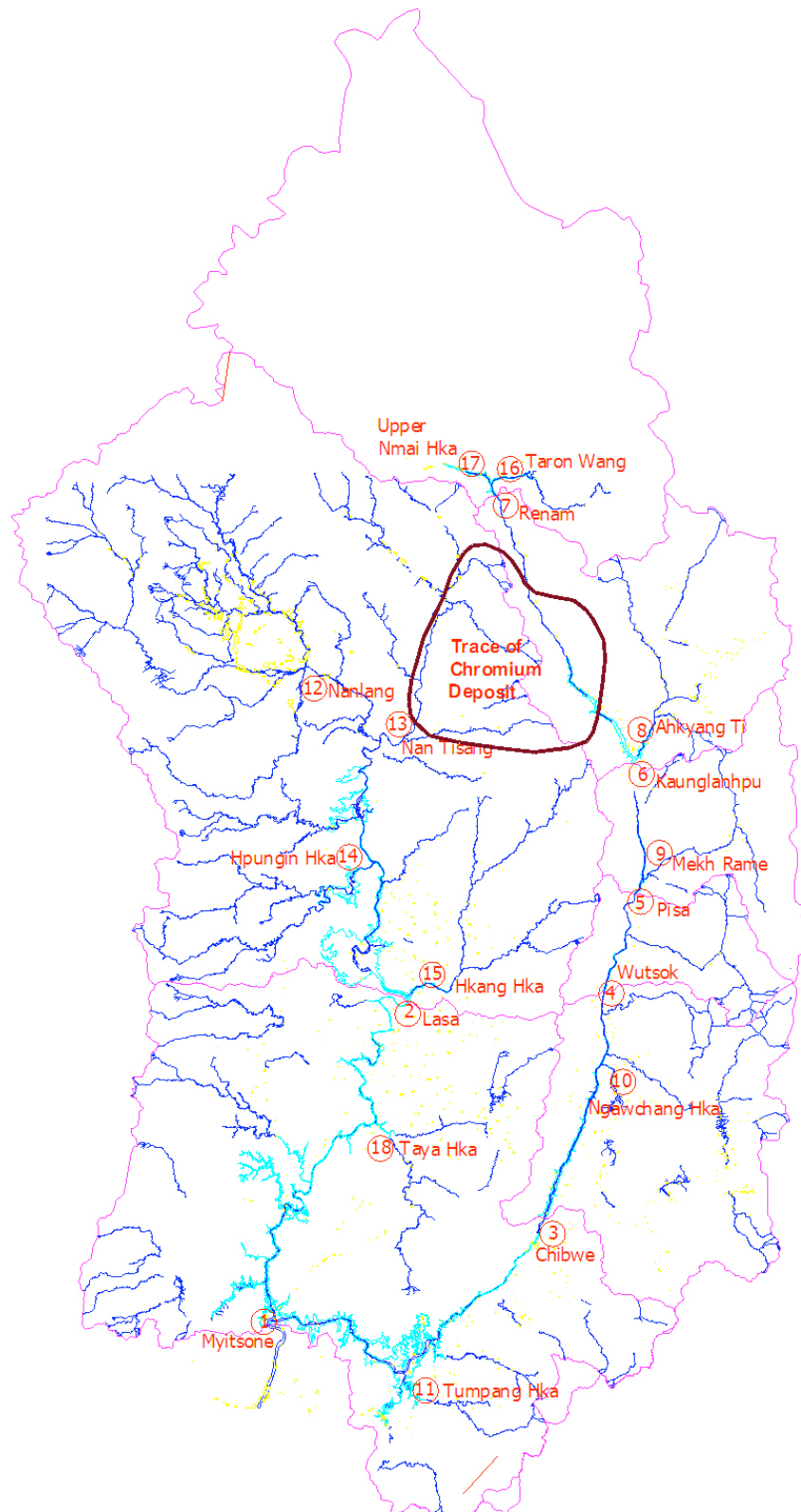
The average annual rainfall at two stations in the area, the period being 1999 to 2008 are as follows.

Station	Annual Rainfall (mm)
1. Myitkyina	2268
2. Putao	4687

These rainfall values are a little higher than the normal values. Based on these data, the catchment area rainfall is again computed to be 3805 mm. The annual runoff is estimated as 133000 million cubic meters. The estimate of CISPDR becomes 108.5 percent of this estimate.

The estimate of CISPDR is considered acceptable in the prefeasibility or feasibility design.

FIG (1) LOCATION MAP OF HYDROPOWER STATION & TRIBUTARIES



3.2. Description of Hydropower Stations

Yenam Hydropower Station

1. Designation of Cascade - Yenam
2. Catchment Area - 11123 km²
3. Average Discharge - 950 m³/s
4. Average Run-Off - 302 Gm³
5. Normal Tank Level - 1010 m
6. Total Storage Capacity - 12.37 Gm³
7. Install Capacity - 1200 MW
8. Average Annual Power Generation - 66.5

GkWh **Fig. 2 Proposed Hydropower Station Site of Yenam**



Kaunglanhpu Hydropower Station

1. Designation of Cascade - Kaunglanhpu
2. Catchment Area - 14655 km²
3. Average Discharge - 1300 m³/s
4. Average Run-Off - 415 Gm³
5. Normal Tank Level - 875 m
6. Total Storage Capacity - 31.72 Gm³
7. Install Capacity - 2700 MW
8. Average Annual Power Generation - 147.3

GkWh



Fig. 3 Proposed Hydropower Station Site of Kaunglanhpu

Pisa Hydropower Station

1. Designation of Cascade - Pisa
2. Catchment Area - 16689 km²
3. Average Discharge - 1490 m³/s
4. Average Run-Off - 472 Gm³
5. Normal Tank Level - 665 m
6. Total Storage Capacity - 3.35 Gm³
7. Install Capacity - 2000 MW
8. Average Annual Power Generation - 110.8 GkWh



Fig. 4 Proposed Hydropower Station Site of Pisa



Wutsok Hydropower Station

1. Designation of Cascad - Wutsok
2. Catchment Area- 18225 km²
3. Average Discharge - 1610 m³/s
4. Average Run-Off - 512 Gm³
5. Normal Tank Level - 525 m
6. Total Storage Capacity - 3.21 Gm³
7. Install Capacity - 1800 MW

8. Average Annual Power Generation - 101.4 GkWh

Fig. 5 Proposed Hydropower Station Site of Wutsok

Chibwe Hydropower Station

1. Designation of Cascade - Chibwe
2. Catchment Area -21734 km
3. Average Discharge- 1880 m³/s
4. Average Run-Off- 598 Gm³
5. Normal Tank Level- 400 m
6. Total Storage Capacity - 19.39 Gm³
7. Install Capacity - 2800 MW
8. Average Annual Power Generation -152.1 GkWh



Fig.6 Proposed Hydropower Station Site of Chibwe



Lasa Hydropower Station

1. Designation of Cascade - Lasa
2. Catchment Area - 15291 km²
3. Average Discharge - 1560 m³/s
4. Average Run-Off - 945 Gm³
5. Normal Tank Level - 370 m
6. Total Storage Capacity - 123.28 Gm³
7. Install Capacity - 1940 MW
8. Average Annual Power Generation - 104.4 GkWh

Fig. 7 Proposed Hydropower Station Site of Lasa

Myitsone Hydropower Station

1. Designation of Cascade - Myitsone
2. Catchment Area - 48782 km²
3. Average Discharge - 4540 m³/s
4. Average Run-Off - 1445 Gm³
5. Normal Tank Level - 230 m
6. Total Storage Capacity - 99.37 Gm³
7. Install Capacity - 4100 MW
8. Average Annual Power Generation - 226 GkWh



Fig. 8 Proposed Hydropower Station Site of Myitsone

3.3. Survey Team

U Nyo, Team Leader

Table. 2

Sr. No.	Designation	Team No. 1	Team No. 2	Team No. 3	Team No. 4
1	Leader Scientist	U Htay Kyawl	U Aung Myo Thu	U Than Tun Aung	U Soe Naing
2	Senior Scientist	U Kyaw Myo Khaine	U Htay Aung	U Aung Bo Bo Kyaw	U Zaw Win Myint
3	Assistant Scientist	U Thet Htun	U Thein Zaw	U Than Htut Win	U Thein Htay Aung

3.4 . Survey Area and Investigation Period

Table. 3

Sr. No.	Team No.	Location	GPS Value	Duration	
				Low flow	High flow
1	Team No.1	Chibwe (Chibwi)	N- 25 54' 01" E - 98 07' 38"	31.1.09 - 18.2.09 5.2.09	25.6.09 - 9.8.09 1.8.09
		Wutsok (Pade)	N- 26 25' 54.5" E- 098 17' 34.5"	12.2.09	7.8 .09
		Ngawchang Hka	N- 26 18' 50.8" E - 98 17' 26.0"	14.2.09	5.8.09
		Myitsone	3494313 903673	4.2.09	1.7.09
2	Team No.2.	Yenan (Renam)	N- 27 41 13" E- 98 01' 43"	23.1.09 - 15.2.09 5.2.09	1.7.09 - 11.8.09 24.7.09
		Putao	N- 27 21' 26.5" E - 97 24' 09.6"	27.1.09	8.8.09
		Nan Tisang	N - 27 04' 54.4" E- 97 45' 58.3"	25.1.09	6.8.09
		Taron Wang	N - 27 42' 18.5" E - 98 03' 40.1"	5.2.09	23.7.09
		Upper Nmai Hka	N- 27 43' 21.1" E- 97 52' 23.3"	7.2.09	26.7.09
		Nan Lang	N- 27 15' 12.7" E- 97 35' 18.3"	26.1.09	7.8.09

3	Team No.3	Ahkyan Ti	3571774	23.1.09 - 24.2.09	8.7.09 - 18.8.09
			1055704	5.2.09	23.7.09
		Kaunglanhpu	3570968	4.2.09	21.7.09
			1058630		
		Pisa	3575643	11.2.09	7.8.09
4	Team No.4		1024533		
		Hkang Hka	N - 26 28' 64.8"	4.2.09 - 24.2.09	24.6.09 - 1.7.09
			E - 97 49' 82.1"	21.2.09	30.6.09
		Taya Hka	N - 26 18' 75.2"	8.2.09	30.6.09
			E - 97 41' 72.1"		
		Lasa	N - 26 28' 43.6"	22.2.09	29.6.09
			E - 97 49' 81.5"		
		Hpunging Hka	N- 26 40' 93.1"	20.2.09	26.6.09
			E - 97 35' 65.8"		

3.5. Notes on Exploration and Experiences of Field Survey Team

The survey team experienced a lot of difficulties in remote area of Kachin State while conducting the survey. Notes on their exploration and experiences were outlines in Appendix-1.

4. MATERIALS AND METHODS

4.1. Materials

4.1.1. Instruments used

- (1) pH meter, water proof pH tester 2, microprocessor-based pH meter with ATC that (9816) floats, OAKTON Instrument, Germany. This is used for measuring of pH value.
- (2) E.C Meter and Temperature Meter, OAKTON Instrument, Germany. This is meter is used for measuring of temperature at the time of samples.
- (3) G.P.S. GARMIN (Trex-H) (Sr. 16Q 315917). It is used to be known for the locations of investigation site in GPS value.
- (4) Sound Level Meter (TES - 1356 A Taiwan)
- (5) Digital Camera, 71007984 Nikon, Japan (Cool pix). This is used for taking for photographs as record.
- (6) Digital Camera, Panasonic, WR 8FACD 1162, Lumix, China. This is used for taking for photographs as record.
- (7) Potable High Volume Air Sampler. The samples were taken to analysis the PM₁₀ & SO₂. It is suitable for remote area.
- (8) High Volume Air Sampler (Respirable Dust Sampler). This sampler is suitable for measurement of PM₁₀ & SO₂ at Myitkyina and Myitsone site.
- (9) Barometer - Measuring of elevation.

4.2. Methods

4.2.1. Methods of surface water sampling

Surface water samples for analyses were collected within the top 5 cm to 100 cm from the water surface (Water Quality Surveys - UNESCO , WHO). According to TOR, all investigation sites were specified by Changjiang Institute of Survey Planning, Design

and Research The investigations were already carried out as the preliminary study of the surface water quality.

Plastic (polythene) containers of 8-litre capacity were used for collection of water samples. They were rinsed three times with water before collecting the sample. The simplest form of water sampling is taking water in a plastic bottle manually.

The sample bottles are labeled as follows:

- (1) Location of water sample taken
- (2) Date
- (3) Time of Sampling
- (4) Type of water

The samples were kept in tightly capped containers well marked by permanent marker. The samples were covered in black polythene bags to protect light and sent to the corresponding laboratories within specified period.

4.2.2. Field methods

Parameters like temperature and pH were measured by water proof pH tester 2, EC and Temperature meter. (The concentrations could be affected by temperature changes.)

Air pollution tests were carried out with high volume air sampler, for particulate matter and sulphur dioxide during the day from 07:00 hr - 22:00 hr and at night from 22:00 hr - 07:00 hr. The high volume air sampler was used at Myitkyina site. The portable air samplers were used at investigation sites in remote areas.

Sound level tests were carried out with sound level meter (TES - 1350 A) during the day 07:00 hr - 22:00 hr and at night from 22:00 hr - 07:00 hr.

4.2.3. Water quality analysis at laboratories

Table. 4

Sr. No.	Parameter	Laboratory				
		Myanma Scientific Technological Research Department	Water Quality Laboratory, Irrigation Department	Toxicology and Environmental Health Laboratory, Department of Health	Plant Protection Myanmar Agriculture Service	Land Use Laboratory, Myanmar Agriculture Service
1	pH		x			
2	Temperature		x			
3	Biochemical Oxygen Demand	x				
4	Chemical Oxygen Demand	x				
5	Total Suspended Solids	x				
6	Oil and Grease			x		
7	Phenol			x		
8	Cyanide	x				

9	Nitrogen					x
10	Phosphorus	x				
11	Arsenic	x				
12	Chromium				x	
13	Mercury			x		
14	Nickel				x	
15	Zinc	x				
16	Particulate Matter ₁₀			x		
17	Sulphur dioxide			x		
18	Sound Levels			x		
19	Alkalinity		x			
20	Hardness		x			
21	Total Dissolved Solids		x			
22	Pesticides				x	
23	Turbidity		x			

4.2.4. Laboratory analysis methods

The water samples were tested in the laboratories by routine methods as described below.

- (1) Total hardness - By EDTA titration method
- (2) Total alkalinity - The estimation is based on simple titration using different indicator
- (3) pH - Measured by water proof pH tester 2, Microprocessor based with ATC, OAKTON Instrument.
(Association of official analytical Chemists, AOAC Knick pH meter 765 Germany)
- (4) Turbidity - Measured by U₁₀ Checker meter
- (5) Temperature - Measured by E.C meter and Temperature meter, OAKTON Instrument.
- (6) Total Dissolved Solids - Measured by TDS meter
- (7) Nickel - Measured by Atomic Absorption Spectrometer
- The bottles are rinsed with nitric acid (1:1 with distilled deionized water)
- Preservation, added 2 ml conc. HNO₃/l of water sample.
Model : A Analyst 200, Technique:
- (8) Chromium - Measured by Atomic Absorption Spectrometer
- The bottles were rinsed with nitric acid (1:1 with distilled deionized water)
- Preservation added 2 ml conc. HNO₃/l of water sample
Model : A Analyst 200, Technique: AAFlame

- (9) Pesticides - Analyzed by Clarus 500, GC with FFD Perkin Elemer
- | | |
|------------------|--|
| (1) Malathion | Analytical method of pesticides and plant Growth Regulator |
| (2) Chlorpyrifos | " |
| (3) Diazinon | " |
| (4) Fenitrothion | " |
| (5) Diamethoate | " |
| (6) Dichlorvos | " |
| (7) Methomyl | " |
| (8) Trizophos | " |

(10) Total Suspended Solids is determined by evaporating method

- (11) Zinc - Zinc content is determined using following apparatus. The bottles were rinsed with nitric acid (1:1 with distilled deionized water) preservation added 2ml/concentrate HNO_3 /l of water sample.

- (1) Atomic Absorption Spectrophotometer
- (2) Burner
- (3) Recorder
- (4) Hollow Cathode Lamps
- (5) Pressure - Reducing valves
- (6) Vent

- (12) Arsenic - by silver diethyl dithiocarbonate method. The bottles were rinsed with nitric acid (1:1 with NaOH to rinsed pH 11.0 for preservation.

(13) Cyanide (CN)

By Spectrophotometer or Filterphotometer using following reagents:

- (1) Chloramine - T solution
- (2) Stock cyanide solution
- (3) Standard cyanide solution
- (4) Pyridine-barbituric acid reagent
- (5) Sodium dihydrogen phosphate
- (6) Sodium hydroxide solution

- (14) Phosphorus - Digestion method was used for Phosphorus. The collected sample was preserved with adding 1ml 30% H_2SO_4 /100 ml of water.

(15) Biochemical oxygen demand (BOD) was measured by the following apparatus

- (1) Incubation bottles, 250 to 300 ml capacity, with ground glass stoppers.
- (2) Air incubator or water bath, thermostatically controlled at $20 \pm 1^\circ\text{C}$, air tight to prevent formation of DQ by algae in the sample.

Reagents used for BOD analysis are :

- (1) Distilled water
- (2) Phosphate buffer solution

- (3) Magnesium sulfate solution
- (4) Calcium Chloride solution
- (5) Ferric Chloride solution
- (6) Acid and alkali solutions
- (7) Sodium sulfite solution
- (8) Seeding

(16) Chemical Oxygen Demand (C.O.D)

By Reflux apparatus :

Reagent used are

- (1) Standard potassium dichromate
- (2) Sulfuric reagent
- (3) Standard Ferrous ammonium sulfate titration

(17) Nitrogen - Spectrophotometer .The water sample was preserved by adding. 8ml. H_2SO_4 /l of sample.

(18) Phenols - Stem-distillable phenolic compounds react with 4-amino antipyrine at pH 7.9 in the presence of potassium ferricyanide to form a coloured antipyrine dye, which is then measured photometrically.
The water samples preservation was done by caustic soda (NaOH) and glass bottles.

The apparatus used for phenols analysis are:

- (1) Spectrophotometer
- (2) pH meter
- (3) Reagent buffer P.1 (0.5 N Ammonium hydroxide)
- (4) Reagent solution P.2 (Phosphate buffer solution pH 7.9
- (5) Reagent solution P-3 (4-ammino antipyrine solution)
- (6) Reagent solution P-4 (Potassium Ferricyanide solution)

(19) Oils and Grease

(petroleum ether and concentrated H_2SO_4)

(20) Mercury - By Dithizone Methods. Preservation was done by treating with HNO_3 to reduce the pH < 2.0.

The apparatus used are :

- (1) Spectrophotometer
- (2) Reparatory funnels
- (3) Glass ware

The Reagents used are:

- (1) Mercury-free water
- (2) Stock mercury solution
- (3) Standard mercury
- (4) Potassium permanganate solution (K Mn O_4)

- (5) Potassium per sulfate solution ($K_2 S_2 O_8$)
- (6) Hydroxylamine hydrochloride solution ($NH_2 OH-HCL$)
- (7) Dithizone solution ($CHCl_3$)
- (8) Sulfuric acid (H_2SO_4) concentration
- (9) Sulfuric acid (H_2SO_4) dilute
- (10) Potassium bromite solution (KBr)
- (11) Chloroform ($CHCl_3$)
- (12) Phosphate-carbonate ($Na_2HPO_4 - 12H_2O$)
- (13) Sodium sulphate (Na_2SO_4)
- (21) Suspended Particulate Matter (SPM)
 By High Volume Sampling Method - The apparatus body is composed of :
 - (1) Upper portion - filter holder and adopter,
 - (2) Second portion - flow controller with timer assembly (with resettable running time meter), and
 - (3) The third portion - motor, orifice and flow recorder.
 High volume sampling unit consists of :
 - (1) HVS shelter
 - (2) Flow recorder
 - (3) Flow controller
 - (4) Elapsed Time Meter
 - (5) Barometer
 - (6) Calibration system for flow rate measurement
 - Orifice calibration unit
 - Differential manometer
 - Calibrated positive displacement meter (roots meter)
 - (7) Filter Conditioning Chamber or Desicator
 - (8) Analytical Balance
 - (9) Light Source
 - (10) Numbering Device
- (22) Sulphur Dioxide (SO_2) - Central Laboratory Test Method (modified West and Gaeke method)
 The reagents and apparatus used are :
 - (1) A solution of potassium tetrachloro-mercurate (TCM)
 - (2) A dichloro sulphilo mercurate complex
 - (3) Paraosamiline and formaldehyde
 - (4) A suitable spectrophotometer
- (23) Ambient Noise By TES sound Level Meter (TES - 1350 A)

Environment conditions required for the apparatus are :

- (1) Altitude up to 2000 meters
- (2) Relative humidity 90% max
- (3) Operation Ambient 0 - 40 °C

Measuring level range 35 dB to 130 dB.

5. RESULT AND ANALYSIS

5.1. Surface Water

The water samples were tested at relevant laboratories in Yangon. The detailed analytical results are shown in the following Table 5 to 22.

Table 5. Laboratory Result of Surface Water at Myitsone

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.88	7.04	
Temperature (A)	C	max 3 C<	29.7	28.7	
Temperature (B)	C	max 3 C<	14.8	22.5	
BOD	mg/l	50	0.6	N.D	
COD	mg/l	250	3.04	3.68	
TSS	mg/l	50	13	550	
Oil and Grease	mg/l	10	2	192	
Phenol	mg/l	0.5	0	3.5	
Cyanide	mg/l	1	< 0.10	< 0.10	
Nitrogen	mg/l	10	22.4	33.2	
Phosphorus	mg/l	2	< 0.05	2.5	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	N.D	N.D	
Mercury	mg/l	0.01	0.007	0.0065	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production -The World Bank).

Temperature(A) At Laboratory

Temperature(B) At Field

TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fibre and biological solids.
Phenol	At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reed, rotting vegetables and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
Phosphorus	Slightly higher than standard limit. It is due to constituent of plants or animal tissues and municipal wastewater. It appears exclusively as phosphate in aquatic environment. The other sources are agricultural fertilizer and manure through ground water.
N.D	Not detected

Table 6. Laboratory Results of Surface Water at Lasa

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.49	7.15	
Temperature (A)	°C	max 3°C<	31.1	28.7	
Temperature (B)	°C	max 3°C<	25.4	20.9	
BOD	mg/l	50	N.D	N.D	
COD	mg/l	250	2	N.D	
TSS	mg/l	50	5	5	
Oil and Grease	mg/l	10	10	3.5	
Phenol	mg/l	0.5	0	5.3	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	19.6	30.24	
Phosphorus	mg/l	2	< 0.50	2.50	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.545	N.D	
Mercury	mg/l	0.01	0.005	0	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production-The

World Bank).

Temperature (A) - At Laboratory

Temperature (B) - At Field

At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.

Phenol

Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run - off or animal waste and decomposition of plants at high flow.

Nitrogen

Phosphorus

Slightly higher than standard limit. It is due to constituent of plants or animal tissues.

N.D

Not detected

Table 7. Laboratory Results of Surface Water at Chibwe (Chibwi)

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.53	7.46	
Temperature (A)	°C	max 3°C<	30.3	28.7	
Temperature (B)	°C	max 3°C<	23.5	33.1	
BOD	mg/l	50	0.2	N.D	
COD	mg/l	250	N.D	N.D	
TSS	mg/l	50	< 5.00	430	
Oil and Grease	mg/l	10	3	3.13	
Phenol	mg/l	0.5	0	5.1	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	19.6	21.16	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.542	N.D	
Mercury	mg/l	0.01	0.0038	0.0032	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note	Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production - The World Bank).
Temperature (A)	At Laboratory
Temperature (B)	At Field
TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fiber and biological solids.
Phenol	At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
N.D	Not detected

Table 8. Laboratory Result of Surface Water at Wutsok

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.54	7.36	
Temperature (A)	°C	max 3°C<	30.4	27.7	
Temperature (B)	°C	max 3°C<	22.9	21.8	
BOD	mg/l	50	0.8	0.2	
COD	mg/l	250	N.D	52.8	
TSS	mg/l	50	< 5.00	200	
Oil and Grease	mg/l	10	6	16.6	
Phenol	mg/l	0.5	0	4.8	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	36.4	40.32	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.508	N.D	
Mercury	mg/l	0.01	0.0055	0.001	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note	Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production-The World Bank).
Temperature (A) -	At Laboratory
Temperature (B) -	At Field
TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant-fibre and biological solids.
Oil and Grease	At high flow, oil and grease level is higher than standard limit. It includes hydrocarbon, fatty acid, soaps, fats, waxes and coal.
Phenol	At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
N.D	Not detected

Table 9. Laboratory Result of Surface Water at Pisa

Parameter	Unit	Limit	Low flow period	High flow period	Remark
PH		6-9	7.54	7.51	
Temperature (A)	°C	max 3°C<	31.3	27.4	
Temperature (B)	°C	max 3°C<	24.2	22.3	
BOD	mg/l	50	N.D	N.D	
COD	mg/l	250	N.D	3.52	
TSS	mg/l	50	20	120	
Oil and Grease	mg/l	10	2	6.19	
Phenol	mg/l	0.5	0	4.3	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	16.8	25.2	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.585	N.D	
Mercury	mg/l	0.01	0.006	0.0047	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note	Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production - The World Bank)
Temperature (A) -	At Laboratory
Temperature (B) -	At Field
TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant-fibre and biological solids.
Phenol	At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
N.D	Not detected

Table 10. Laboratory Result of Surface Water at Kaunglanhpu

Parameter	Unit	Limit	Low flow period	High flow period	Remark
PH		6-9	7.6	7.1	
Temperature (A)	°C	max 3°C<	31.6	27.9	
Temperature (B)	°C	max 3°C<	14.5	26.8	
BOD	mg/l	50	N.D	N.D	
COD	mg/l	250	N.D	N.D	
TSS	mg/l	50	5	100	
Oil and Grease	mg/l	10	3	3.43	
Phenol	mg/l	0.5	0	3.5	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	16.8	69..00	
Phosphorus	mg/l	2	< 0.50	2.5	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.588	N.D	
Mercury	mg/l	0.01	0.005	0	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note	Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production - The World Bank).
Temperature (A) -	At Laboratory
Temperature (B) -	At Field
TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant-fibre and biological solids.
Phenol	At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
N.D	Not detected

Table 11. Laboratory Result of Surface Water at Yenam

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.43	7.04	
Temperature (A)	°C	max 3°C<	30.1	27.1	
Temperature (B)	°C	max 3°C<	13.9	21.4	
BOD	mg/l	50	0.02	N.D	
COD	mg/l	250	4	1.84	
TSS	mg/l	50	< 5.00	15	
Oil and Grease	mg/l	10	2	2.2	
Phenol	mg/l	0.5	0	4.3	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	19.6	15.12	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.547	N.D	
Mercury	mg/l	0.01	0.006	0.0024	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note	Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production - The World Bank).
Temperature (A) -	At Laboratory
Temperature (B) -	At Field
TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fibre and biological solids.
Phenol	At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
N.D	Not detected

Table 12. Laboratory Result of Surface Water at Ahkyang Ti

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.54	7.2	
Temperature (A)	°C	max 3°C<	32.0	27.8	
Temperature (B)	°C	max 3°C<	16.1	26.2	
BOD	mg/l	50	N.D	N.D	
COD	mg/l	250	N.D	N.D	
TSS	mg/l	50	5	400	
Oil and Grease	mg/l	10	1	11.13	
Phenol	mg/l	0.5	0	3.2	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	19.6	32.76	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.56	N.D	
Mercury	mg/l	0.01	0.0047	0	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note	Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production-The World Bank).
Temperature (A) -	At Laboratory
Temperature (B) -	At Field
TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fiber and biological solids.
Oil and Grease	At high flow, oil and grease level is higher than standard limit. It includes hydrocarbon, fatty acid, soaps, fats, waxes and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
N.D	Not detected

Table 13. Laboratory Result of Surface Water at Mekh Rame

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.65	7.5	
Temperature (A)	°C	max 3°C<	30.7	27.8	
Temperature (B)	°C	max 3°C<	15.9	23.7	
BOD	mg/l	50	N.D	N.D	
COD	mg/l	250	N.D	N.D	
TSS	mg/l	50	15	80	
Oil and Grease	mg/l	10	3	4.57	
Phenol	mg/l	0.5	0	4.5	
Cyanide	mg/l	1	< 0.1	< 0.1	
Nitrogen	mg/l	10	19.6	30.2	
Phosphorus	mg/l	2	< 0.50	< 0.50	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.585	N.D	
Mercury	mg/l	0.01	0.0062	0.0057	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.0	

Note	Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production - The World Bank).
Temperature (A) -	At Laboratory
Temperature (B) -	At Field
TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fiber and biological solids.
Phenol	At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
Phosphorus	Slightly higher than standard limit. It is due to constituent of plants or animal tissues and municipal wastewater. It appears exclusively as phosphate in aquatic environment. The other sources are agricultural fertilizer and manure through ground water.
N.D	Not detected

Table 14. Laboratory Result of Surface Water at Ngawchang Hka

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.56	7.24	
Temperature (A)	°C	max 3°C<	30.7	27.6	
Temperature (B)	°C	max 3°C<	24.8	21.9	
BOD	mg/l	50	0.4	N.D	
COD	mg/l	250	N.D	5.28	
TSS	mg/l	50	250	170	
Oil and Grease	mg/l	10	4	3.9	
Phenol	mg/l	0.5	0	4.8	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	22.4	7.75	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.565	N.D	
Mercury	mg/l	0.01	0	0.0059	
Nickel	mg/l	0.5	N.D	N.D	

Zinc	mg/l	2	< 1.0	< 1.00	
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Note Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production (The World Bank).

Temperature (A) At Laboratory

Temperature (B) At Field

TSS At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fiber and biological solids.

Phenol At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.

Nitrogen Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.

N.D Not detected

Table 15. Laboratory Result of Surface Water at Tumpang Hka

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.61	7.52	
Temperature (A)	°C	max 3°C<	30.3	28.7	
Temperature (B)	°C	max 3°C<	21.8	33.6	
BOD	mg/l	50	0.6	N.D	
COD	mg/l	250	2.0	3.68	
TSS	mg/l	50	< 5.00	100	
Oil and Grease	mg/l	10	4.0	3.4	
Phenol	mg/l	0.5	0	5.2	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	33.6	42.12	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.548	N.D	
Mercury	mg/l	0.01	0.0044	0.0038	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.0	

Note	Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production (The World Bank).
Temperature (A) -	At Laboratory
Temperature (B) -	At Field
TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fiber and biological solids.
Phenol	At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
N.D	Not detected

Table 16. Laboratory Result of Surface Water at Nan Lang

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.51	7.38	
Temperature (A)	°C	max 3°C<	29.7	27.6	
Temperature (B)	°C	max 3°C<	18.9	26.4	
BOD	mg/l	50	N.D	0.2	
COD	mg/l	250	N.D	8.8	
TSS	mg/l	50	< 5.00	60	
Oil and Grease	mg/l	10	1	3.03	
Phenol	mg/l	0.5	0	4.8	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	31.4	17.64	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	N.D	N.D	
Mercury	mg/l	0.01	0.0063	0.0021	
Nickel	mg/l	0.5	N.D	0.011	
Zinc	mg/l	2	< 1.0	< 1.0	

Note	Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production (The World Bank).
Temperature (A) -	At Laboratory
Temperature (B) -	At Field
TSS	At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fiber and biological solids.
Phenol	At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.
Nitrogen	Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.
N.D	Not detected

Table 17. Laboratory Result of Surface Water at Nan Tisang

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.6	6.64	
Temperature (A)	°C	max 3°C<	27.9	27.6	
Temperature (B)	°C	max 3°C<	18	23.8	
BOD	mg/l	50	N.D	0.4	
COD	mg/l	250	N.D	5.28	
TSS	mg/l	50	< 5.00	20	
Oil and Grease	mg/l	10	8	2.3	
Phenol	mg/l	0.5	0	4.5	
Cyanide	mg/l	1	< 0.1	< 0.1	
Nitrogen	mg/l	10	20.4	63.0	
Phosphorus	mg/l	2	< 0.50	< 0.1	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	N.D	N.D	
Mercury	mg/l	0.01	0	0.0018	

Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.0	

Note Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production - The World Bank)

Temperature (A) - At Laboratory

Temperature (B) - At Field

Phenol At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.

Nitrogen Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.

N.D Not detected

Table 18. Laboratory Result of Surface Water at Hpungin Hka

Parameter	Unit	Limit	Low flow period	High flow period	Remark
PH		6-9	7.56	7.21	
Temperature (A)	°C	max 3°C<	31.2	28.7	
Temperature (B)	°C	max 3°C<	22.4	28.7	
BOD	mg/l	50	N.D	N.D	
COD	mg/l	250	N.D	1.84	
TSS	mg/l	50	5	15	
Oil and Grease	mg/l	10	3	1.7	
Phenol	mg/l	0.5	0	5.4	
Cyanide	mg/l	1	< 0.1	< 0.1	
Nitrogen	mg/l	10	16.8	48.38	
Phosphorus	mg/l	2	< 0.50	7.5	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.575	N.D	
Mercury	mg/l	0.01	0	0	

Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.0	

Note Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production (The World Bank)).

Temperature (A) - At Laboratory

Temperature (B) - At Field

Phenol At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.

Nitrogen Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.

Phosphorus Slightly higher than standard limit. It is due to constituent of plants or animal tissues and municipal wastewater. It appears exclusively as phosphate in aquatic environment. The other sources are agricultural fertilizer and manure through ground water.

N.D Not detected

Table 19. Laboratory Result of Surface Water at Hkang Hka

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.53	7.14	
Temperature (A)	°C	max 3°C<	29.7	28.7	
Temperature (B)	°C	max 3°C<	21.7	20.9	
BOD	mg/l	50	0.2	N.D	
COD	mg/l	250	2	N.D	
TSS	mg/l	50	< 5.00	105	
Oil and Grease	mg/l	10	2	3.45	
Phenol	mg/l	0.5	0	4.8	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	33.6	24.19	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.477	N.D	

Mercury	mg/l	0.01	0.0047	0.0047	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production-The World Bank).

Temperature (A) - At Laboratory

Temperature (B) - At Field

TSS At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fibre and biological solids.

Phenol At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.

Nitrogen Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.

N.D Not detected

Table 20. Laboratory Result of Surface Water at Taron Wang

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.52	6.53	
Temperature (A)	°C	max 3°C<	31.0	27.7	
Temperature (B)	°C	max 3°C<	20.64	19.5	
BOD	mg/l	50	0.2	N.D	
COD	mg/l	250	N.D	5.28	
TSS	mg/l	50	< 5.00	10	
Oil and Grease	mg/l	10	3	4.5	
Phenol	mg/l	0.5	0	4.7	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	22.6	42.84	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	0.01	
Chromium	mg/l	0.5	0.572	N.D	

Mercury	mg/l	0.01	0.0065	0.0028	
Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.0	

Note Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production (The World Bank).

Temperature (A) - At Laboratory

Temperature (B) - At Field

Phenol At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.

Nitrogen Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.

N.D Not detected

Table 21. Laboratory Result of Surface Water at Upper Nmai Hka

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.53	7.18	
Temperature (A)	°C	max 3°C<	30.5	27.6	
Temperature (B)	°C	max 3°C<	11.4	20.7	
BOD	mg/l	50	0.6	0.2	
COD	mg/l	250	N.D	3.52	
TSS	mg/l	50	< 5.00	300	
Oil and Grease	mg/l	10	5	4.19	
Phenol	mg/l	0.5	0	4.3	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	14	45.36	
Phosphorus	mg/l	2	< 0.50	< 0.10	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.549	N.D	
Mercury	mg/l	0.01	0.0057	0.0024	

Nickel	mg/l	0.5	N.D	N.D	
Zinc	mg/l	2	< 1.0	< 1.00	

Note Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production-The World Bank).

Temperature (A) - At Laboratory

Temperature (B) - At Field

TSS At high flow, TSS increased more than standard limit due to increased flow. It includes clay, silt, plant -fiber and biological solids.

Phenol At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.

Nitrogen Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.

N.D Not detected

Table 22. Laboratory Result of Surface Water at Taya Hka

Parameter	Unit	Limit	Low flow period	High flow period	Remark
pH		6-9	7.5	7.34	
Temperature (A)	°C	max 3°C<	29.8	28.7	
Temperature (B)	°C	max 3°C<	27.9	26.9	
BOD	mg/l	50	0.2	N.D	
COD	mg/l	250	4.0	N.D	
TSS	mg/l	50	< 5.0	5	
Oil and Grease	mg/l	10	0	1.97	
Phenol	mg/l	0.5	0	5	
Cyanide	mg/l	1	< 0.1	< 0.10	
Nitrogen	mg/l	10	28	27.2	
Phosphorus	mg/l	2	< 0.50	2.5	
Arsenic	mg/l	0.1	< 0.01	< 0.01	
Chromium	mg/l	0.5	0.413	N.D	
Mercury	mg/l	0.01	0.0036	0.0065	

Nickel	mg/l	0.5	N.D	0.007	
Zinc	mg/l	2	< 1.0	< 1.00	

Note Limits for Process Wastewater, Domestic Sewage, and Contaminated Storm water Discharged to Surface Waters, for General Application (Pollution Prevention and Abatement Handbook 1998 Toward Cleaner Production (The World Bank).

Temperature (A) - At Laboratory

Temperature (B) - At Field

Phenol At high flow the level is higher than standard limit due to high volume flow. It includes decomposition of some species of higher plants and reeds, rotting vegetables and coal.

Nitrogen Nitrogen level is higher than standard limit, due to polluted discharge both at low flow and high flow situations. The source is agricultural run-off or animal waste and decomposition of plants at high flow.

Phosphorus Slightly higher than standard limit. It is due to constituent of plants or animal tissues and municipal wastewater. It appears exclusively as phosphate in aquatic environment. The other sources are agricultural fertilizer and manure through ground water.

N.D Not detected

Table 23. Five specific Water Quality Parameters observed at some stations

Sr. No.	Station Observed	Water Quality Parameter				
		T.S.S	Oil and Grease	Phenol	Nitrogen	Phosphorus
A	Mali Hka Basin					
1	Nanlang	✓	—	✓	✓	—
2	Nan Tisang	—	—	✓	✓	—
3	Hpungin Hka	—	—	✓	✓	✓
4	Hkang Hka	✓	—	✓	✓	—
5	Lasa	—	—	✓	✓	✓
6	Taya Hka	—	—	✓	✓	✓
B	Nmai Hka Basin					
1	Upper Nami Hka		—	✓	✓	—

2	Toron Wang	—	—	✓	✓	—
3	Renam	—	—	—	✓	—
4	Ahkyang Ti	✓	✓	✓	✓	—
5	Kaunglanhpu	✓	—	—	✓	✓
6	Mekh Rame	✓	—	✓	✓	—
7	Piza	✓	—	✓	✓	—
8	Wutsok	✓	✓	✓	✓	—
9	Ngawchang Hka	✓	—	✓	✓	—
10	Chibwe	✓	—	✓	✓	—
11	Tumpang Hka	✓	—	✓	✓	—
C	Myitsone	✓	✓	✓	✓	✓

5.2 Evaluation of Parameters of the Project Area

5.2.1. pH

pH is a measure of the acidity or alkalinity of a liquid or solid material. The pH value of natural water is an important index of acidity or alkalinity. Under natural conditions, the value of pH in the surface water ranges from 5.0 and 8.6, while in some cases, the value may be considerably higher or lower than this range.

Numeric value of pH indicates the relative acidity or alkalinity. The specified range is 0 to 14 and 7 indicates neutral, less than 7 shows acidity while more than 7.0 is alkalinity.

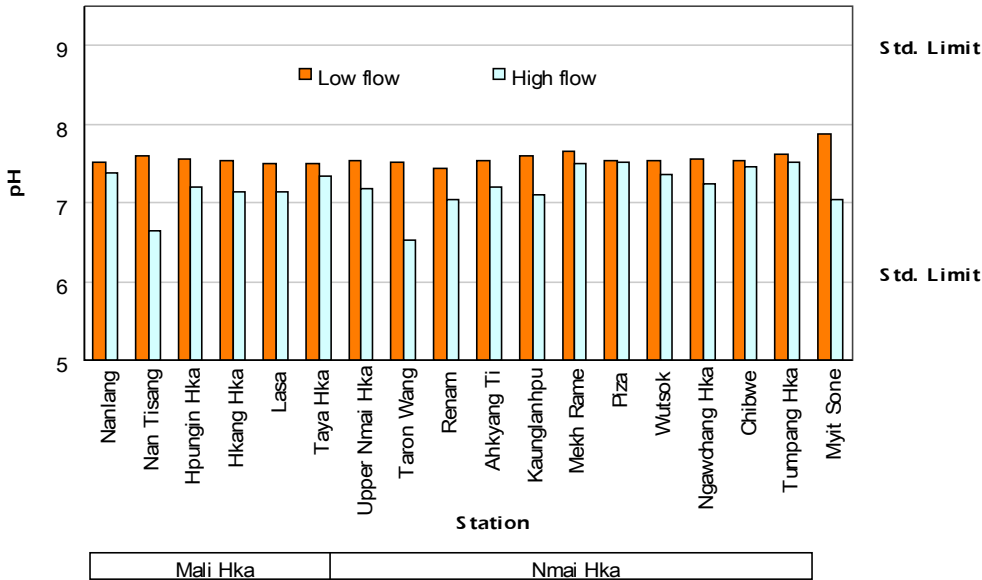
The pH value of water may be determined by a wide variety of pH meter which are battery-operated or by simple electric current power. They are equipped with glass and reference electrodes. Before use, calibration of pH meter is important. This can be obtained by using standard buffered solutions. pH meters should be stored in a dry place to prevent moisture.

The pH may also be measured by comparison with standard indicators and buffered solutions using various comparators or colourimeters as described in standard method publications (APHA, 1971; IBP No. 8, 1971).

Being the important criterion of the quality of water, pH also serves as an auxiliary value when calculating a number or other characteristics of the quality of water such as free carbonic acid and free hydrogen sulphide. The pH value is affected by the increase in the content of coloured humus substances, i.e. humic acids and fulvic acids, a number of hydrolyzing compounds as well as various acid and alkalis which can penetrate the

body of water along with industrial waste waters. In pure or slightly polluted water, the values of pH are determined mainly by the correlation between the concentrations of free carbondioxide and bicarbonate ions. The pH value is determined by the interaction of numerous substances contained in water, including those which are chemically and biochemically unstable.

Fig. 7.1 pH Value of Surface Water



Findings

The pH of study area is found to be between 7 and 8 in low flow period while 6.5 to 7.5 in high flow period. The low pH may be due to dilution of water body in rainy season. It is within standard limit 6.0 - 9.0 both in low and high flow period.

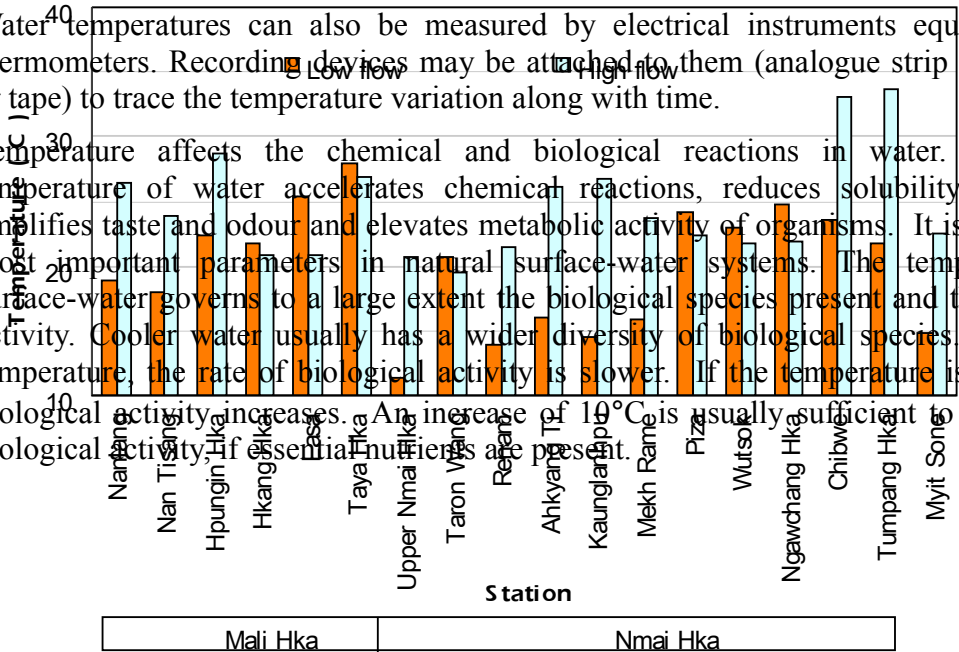
5.2.2. Temperature

Temperatures were measured on-site by a standard laboratory thermometer armoured by metal protective casing. These are calibrated in scales suitable for normal water temperatures.

Fig. 7.2 Temperature of Surface Water

Water temperatures can also be measured by electrical instruments equipped with thermometers. Recording devices may be attached to them (analogue strip chart paper or tape) to trace the temperature variation along with time.

Temperature affects the chemical and biological reactions in water. A rise in temperature of water accelerates chemical reactions, reduces solubility of gases, amplifies taste and odour and elevates metabolic activity of organisms. It is one of the most important parameters in natural surface-water systems. The temperature of surface-water governs to a large extent the biological species present and their rate of activity. Cooler water usually has a wider diversity of biological species. At lower temperature, the rate of biological activity is slower. If the temperature is increases, biological activity increases. An increase of 10°C is usually sufficient to double the biological activity, if essential nutrients are present.



Findings

Temperature of surface water at low flow is always lower than the high flow in all observed stations. Low flow temperature ranges from 11.4°C to 27.9°C while high flow temperature ranges from 19.5°C to 33.6°C. This may be due to ice melting and several changes in the upstream area in the low flow season.

The temperature of water is one of the most important characteristics which determines to a considerable extent the trends and tendencies of changes in water quality. Temperature is an important factor affecting ions and phase equilibrium and influence the rate of biochemical processes which accompany the changes of concentration and content of organic and mineral substances. It is generally known that the rate of numerous chemical reactions including catalytic and enzymatic ones depends, considerably on changes in temperature (on the average 2 to 3 times for every 10°C). Consequently, when discussing parameters such as sedimentation, mobilization of undissolved substances, solution of gas and their escape from water into the atmosphere, the processes of chemical and biochemical self-purification, formation of secondary pollutants and others, it is necessary to know the temperature of the water, air and in some cases the bottom deposits. The shifting of various dynamic equilibrium such as concentrations of carbonates, sulphides, or degree of alkalinity, or electrical conductivity are also affected by temperature changes.

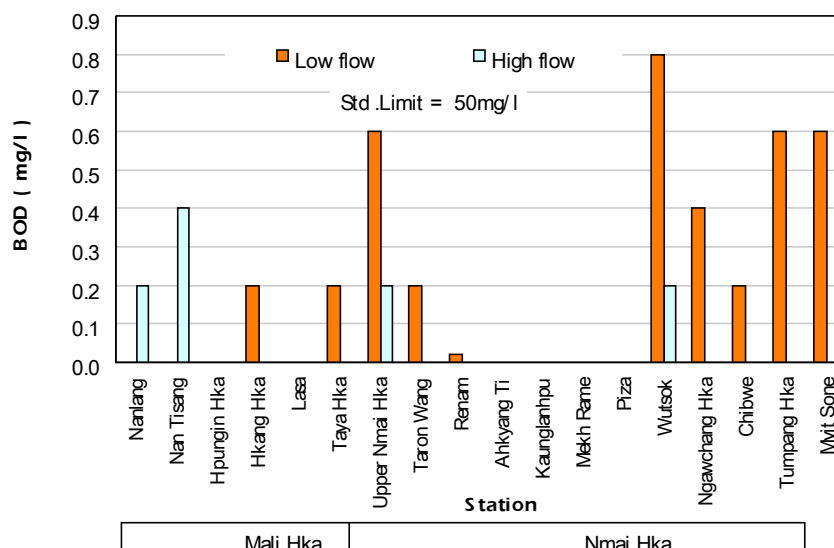
In some cases temperature is direct index of the influence of man-made factors on the quality of water (Thermal pollution). Temperature measurements may also become useful in the studies of such parameters as volume distribution of water or evaporation.

5.2.3. BOD

BOD is a measure of the amount of oxygen consumed in the biological processes that break down organic matter in water. The greater the BOD, the greater the degree of pollution.

Biochemical Oxygen Demand has a direct relation to life of organic compounds which are main causes of pollutions. Micro organisms need oxygen, when they divide organic compound. If there has a lot of organic compounds, oxygen demand is increased. Animal manure and plant residues are sources of organic compounds. BOD is defined basically as the amount of oxygen required by bacteria, while stabilizing decomposable organic matter under aerobic condition.

Fig. 7.3 BOD of Surface Water



Findings

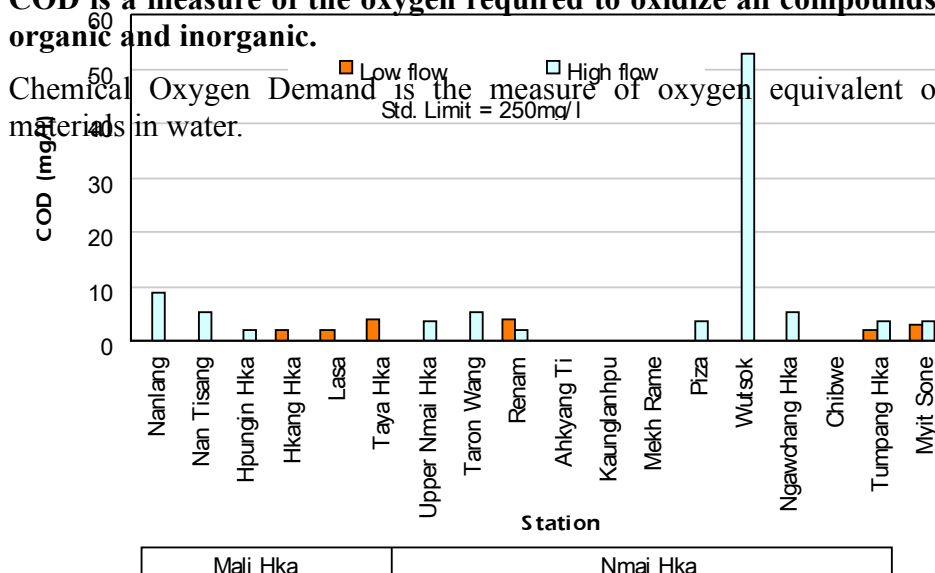
According to the laboratory results the level of BOD is lower than the limit 50 mg/l specified for general application. BOD of high flow at Myitsone, Lasa, Chibwe, Kaunglanhpu, Yenam, Ahkyang Ti, Tumpang Hka, Hpungin Hka and Taya Hka is not detected at present. At low flow, BOD of Myitsone, Hkang Hka, Taya Hka, Upper Nmai Hka, Toron Wang, Wutsok, Ngwacahan Hka, Chibwe, Tupang Hka is found to be between 0.2 to 0.8 mg/l. The water at Yenam site has the negligible amount in BOD.

5.2.4. COD

Fig. 7.4 COD of Surface Water

COD is a measure of the oxygen required to oxidize all compounds in water, both organic and inorganic.

Chemical Oxygen Demand is the measure of oxygen equivalent of most organic materials in water.



Findings

COD in surface water is found to be less than 2.0 mg/l at low flow. The COD of all station observed at high flow period is lower than 10 mg/l except at Wutsok station but it is still very much lower than the specified limit of 250 mg/l. The level of COD is not in a critical condition at present situation. The high level in Wutsok area may be due to chemical reaction of organic materials from the forest.

5.2.5. Total suspended solids (TSS)

TSS is a measure of the suspended solids in wastewater, effluent, or water bodies.

Total suspended solids exist in water in both suspended and dissolved form.

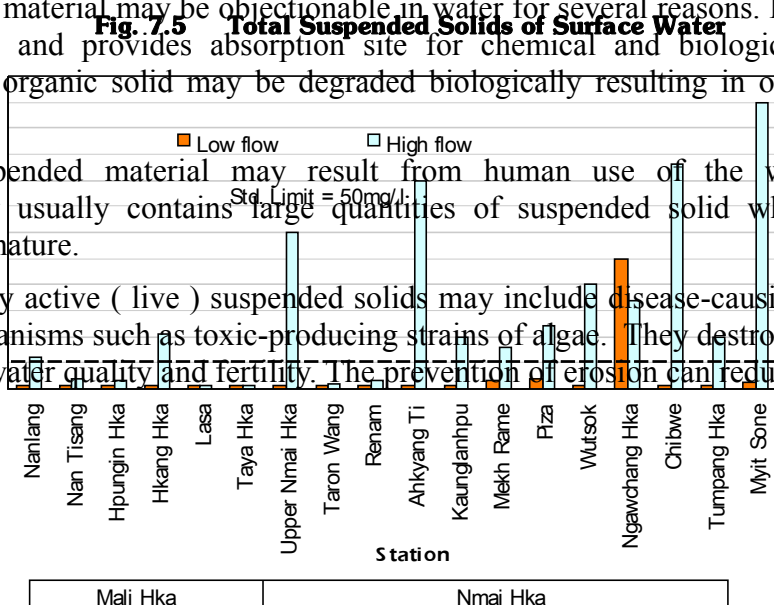
Total Suspended Solids in water may consist of inorganic or organic particles of immiscible liquids. Inorganic solids such as clay, silt, and other soil constituents are common in surface water. Organic materials such as plant fibers and biological solids (algal cells, bacteria etc.) are also common constituents of surface waters. These materials are often natural contaminant resulting from the erosive action of water. Suspended material is seldom a constituents from the erosive action of water flowing over surfaces.

Suspended solids in water are mostly suspended fine particles of insoluble materials including sand, silt, clay, debris from vegetation growth, algae, chlorophyll and other buoyant type substances. These materials originate from shore erosion through wind and wave action, tributary inputs, biological activities and from pollution sources. Suspended solid reduce the transparency of water. These inhibit the penetration of light thereby reducing the photosynthesis processes and the production of oxygen. The photosynthesis is an important sources of oxygen in water.

Suspended material may be objectionable in water for several reasons. It is aesthetically displeasing and provides absorption site for chemical and biological agent. The suspended organic solid may be degraded biologically resulting in objectionable by-products.

Other suspended material may result from human use of the water. Domestic wastewater usually contains large quantities of suspended solid which are mostly organic in nature.

Biologically active (live) suspended solids may include disease-causing organisms as well as organisms such as toxic-producing strains of algae. They destroy ecosystem and affect the water quality and fertility. The prevention of erosion can reduce the formation of TSS.



Findings

Myitsone, Chibwe, Ahkyang Ti and Upper Nmai Hka stations are extremely high in TSS amounting 300 to 550 mg/l. At Wutsok, Piza, Kaunglanhpu, Mekh Rane, Ngawchan Hka, Tumpang Hka and Hkang Hka sites the amount of TSS is found to be between 80 to 200 mg/l. Myitsone and Chibwe sites are situated in downstream part of the project area and fine particles are deposited at these sites which are polluted by TSS. Other sites are polluted, due to high flow which consists of clay, silt, plant-fiber and biological solids.

TSS level is less than 60 mg/l in the remaining sites. At high flows, different results were obtained for the different flood duration, rain fall pattern, morphology of rivers, time of survey and vegetation. At low flow, the results of all stations are within the specified limit. Soil conservation can help reduction of TSS.

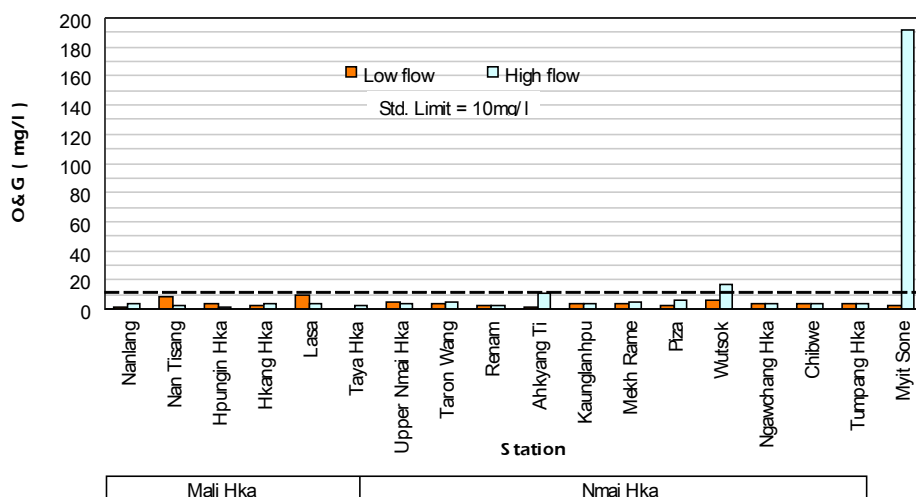
5.2.6. Oil and grease (O & G)

These are also important items for water quality. They include hydrocarbons, fatty acids, soaps, fats, waxes, oils and any other materials .

Oils and Greases are particularly resistant to an aerobic digestion, and when present in sludge they cause excessive scum accumulation in digesters, clog the pores of filter, and deter the use of the sludge as fertilizer.

A knowledge of the quantity of oil and grease present in a waste water is helpful in overcoming difficulties in plant operation.

Fig. 7.6 – Oil & Grease of Surface Water



Findings

Oil and grease composition in the surface water of Myitsone site is approximately higher than standard limit of 10.0 mg/l. The O & G of Myitsone is found to be 192 mg/l. O & G of Wutsok and Ahkyang Ti sites found between 11.13 to 16.60 mg/l. It might be the result of fats, waxes, oil and other materials produced from local diesel and gasoline motor boats and different kinds of heavy machineries and engines used in gold mining in the upstream of river.

5.2.7. Phenol

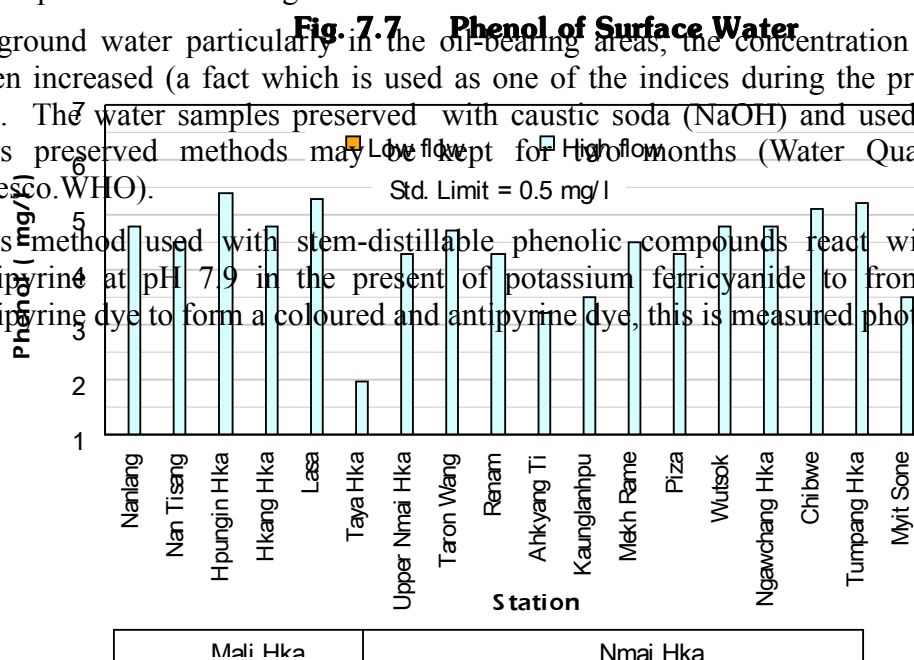
Phenols are organic compounds that are produced from decomposition of some species of plants, and from metabolic process of aquatic organisms and as by-products of petroleum refining, and textile, dye, and resin manufacturing. Low concentrations cause taste and odor problems in water; higher concentrations can kill aquatic life and human.

The properties of phenols and their influence on organisms also differ considerably. All this hinders the control and the evaluation of the quality of Phenols-containing waters. When the phenols concentration is several milligrams or more per litre, the phenols may exert an osmotic pressure effect on the aquatic organisms and become dangerous for warm-blooded animals and man. At much lower concentrations (one or more $\mu\text{g/l}$), the phenol odour and taste. It is therefore recommended to purify such water with chlorination before treatment.

Under natural conditions, phenols are formed during metabolic processes of aquatic organisms, particularly during the biochemical break down and transformation of organic substances from dead algae. Phenols may also enter the water during the decomposition of some species of higher plants and reeds. They are often detected in water in contact with fallen leaves of some species on trees, oak or in the overgrowth of seeds. It is known that some of these phenols also form compounds which impart chlorophenol odour during the chlorination.

In ground water particularly in the oil-bearing areas, the concentration of phenol is often increased (a fact which is used as one of the indices during the prospecting for oil). The water samples preserved with caustic soda (NaOH) and used glass bottle. This preserved methods may be kept for high flow months (Water Quality Surveys Unesco.WHO).

This method used with stem-distillable phenolic compounds react with 4 -amino antipyrine at pH 7.9 in the presence of potassium ferricyanide to form a coloured antipyrine dye to form a coloured and antipyrine dye, this is measured photometrically.



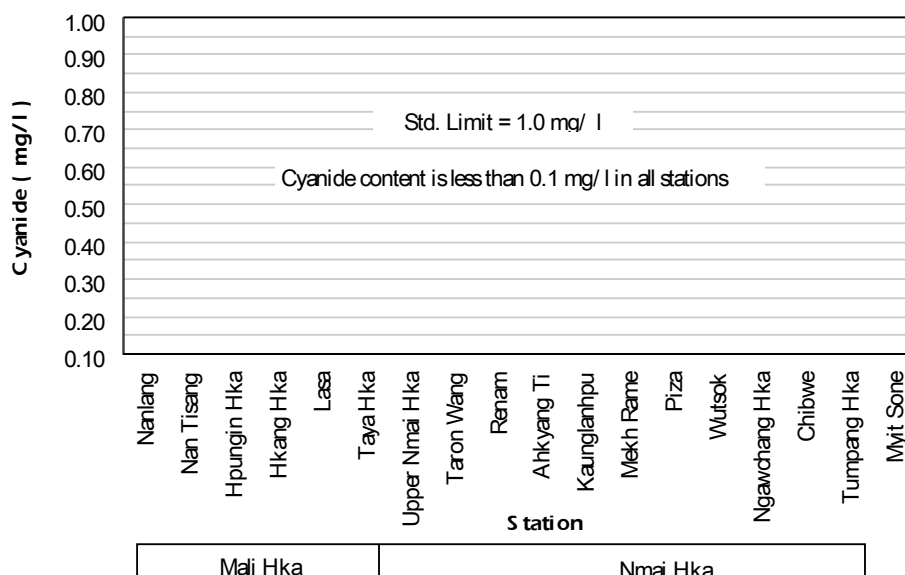
Findings

The content of phenol in surface water in high flow of all proposed hydropower station sites and tributaries observed is found to be much higher than standard limit of 0.5 mg/l. Phenol in surface water of all sites is found to be between 2 to 5.4 mg/l. The reason of higher content of phenol during high flood period may be due to the decomposition of some species of higher plants in water, and fallen leaves of some tree species, and reeds from the forest in the catchment area.

5.2.8. Cyanide (CN)

"Cyanide" refers to all of the CN groups in cyanide compounds can be determined as the cyanide ion. Cyanide are found in a number of foods and plants. These are found, although in small amounts, in apple seeds, mango stones, peach stones and bitter almonds. In plants, cyanides are usually bound to sugar molecules in the form of cyanogenic glycosides. Cyanides are produced by certain bacteria, fungi and algae. Many cyanide-containing compounds are highly toxic but some are not. The most dangerous cyanides are hydrogen cyanides (HCN). The sample treated with caustic soda (NaOH) to raise to pH 11.0 for preservation.

Fig. 7.8 Cyanide of Surface Water



Findings

The CN level in all station observed is less than 0.1 mg/l while specified standard limit of cyanide is 1.0 mg/l. Therefore it can be said that there is no problem of cyanide at present in the project area.

5.2.9. Nitrogen (N)

Sources of Nitrogen in aquatic systems is decomposition of plants, animal waste, chemical fertilizers and wastewater discharges.

Nitrogen from these sources may enter directly into waterways through surface run-off or through the groundwater. Nitrogen compounds can be oxidized to nitrate by soil bacteria .

Ammonia is found as a gas at normal temperature and pressures in natural water systems. The presence of ammonium ions in unpolluted water is connected with the process of the biochemical decomposition of protein substances. An increase in the concentration of ammonium ions therefore, is observed when aquatic organisms are dying-off, especially in the zone of the aggregation. The amplitude of seasonal fluctuations of ammonium ions reflects the nutrition of the body of water and its pollution by organic nitrogen containing substances contained in household and industrial sewage.

The nitrates are present in applicable amount in surface water, except for a periods of intensive development of phytoplankton in bodies of water. Increased concentrations of nitrates may indicate faecal pollution of water body in the preceding period. The high nitrate content in potable water also harmful for children.

They cause anaemia (Methaemoglobinaemia)

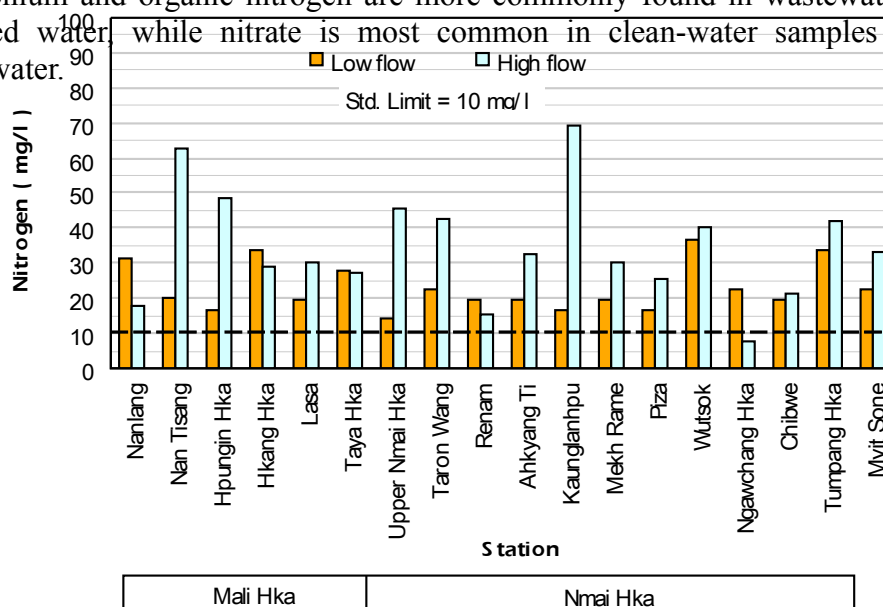
The collected water sample preserved by adding 0.8 ml sulphuric acid per litre of sample.

A task force recommended a 20 to 30 percent decrease in nitrogen loading to reduce the size and effects of this zone similar hypoxic zones occur near mouths of many other rivers that drain agricultural area (Environmental Science Page. 184).

Nitrate poisoning in infant animals, including humans can cause serious problem leading to death. The natural oxidation changes nitrite to nitrate quickly and so significant quantities of nitrites are not found in natural water.

Fig. 7.9 Nitrogen of Surface Water

Ammonium and organic nitrogen are more commonly found in wastewater and other polluted water, while nitrate is most common in clean-water samples and treated wastewater.



Findings

Due to agricultural run-off or animal waste and decomposition of plants, the project area has high content of Nitrogen in surface water. It was found that there is no evidence of chemical fertilizer usage in this area. There was significantly large content of Nitrogen in Kaunglanhpu, Nan Tisang, Hpungin Hka, Upper Hka, Toron Wang, Wutsok, and Tumpang Hka amounting to 40.32 to 69.00 mg/l. These might be due to decomposition of animal waste and plants.

Under natural conditions, the concentration of both organic and mineral nitrogen is subject to regular seasonal fluctuations which are connected with biological development cycles of aquatic organisms, mainly phytoplankton, zooplankton, and bacterioplankton.

Organic nitrogen-containing compound may be formed as a result of photo and biosynthetic processes by aqueous organism and decomposition of plants and enter the river at both low flow and high flow. Another source of nitrogen may come from the natural organic fertilizer from sewage and manure through ground water. The pollution can be reduced by collection feedlot and barnyard run-off in infiltration ponds together with soil conservation practices such as terracing, contour plowing, strip farming, leaving crop residue on fields, ground cover on waterways and cultivation of perennial crops.

5.2.10. Phosphorus (P)

Phosphorus is an essential chemical food element that can contribute to the eutrophication of lakes and other water bodies. Increased phosphorus levels is the result of phosphorus- containing materials which discharged into surface waters.

Phosphorus appears exclusively as phosphate (PO_4) in aquatic environments. There are several forms of phosphate, including orthophosphates, condensed phosphates and organically bonded phosphates. Phosphates may exist in soluble state or particulate form or constituents of plant or animal tissue. Runoff from the agricultural areas and municipal wastewater are major contribution of phosphate in surface water.

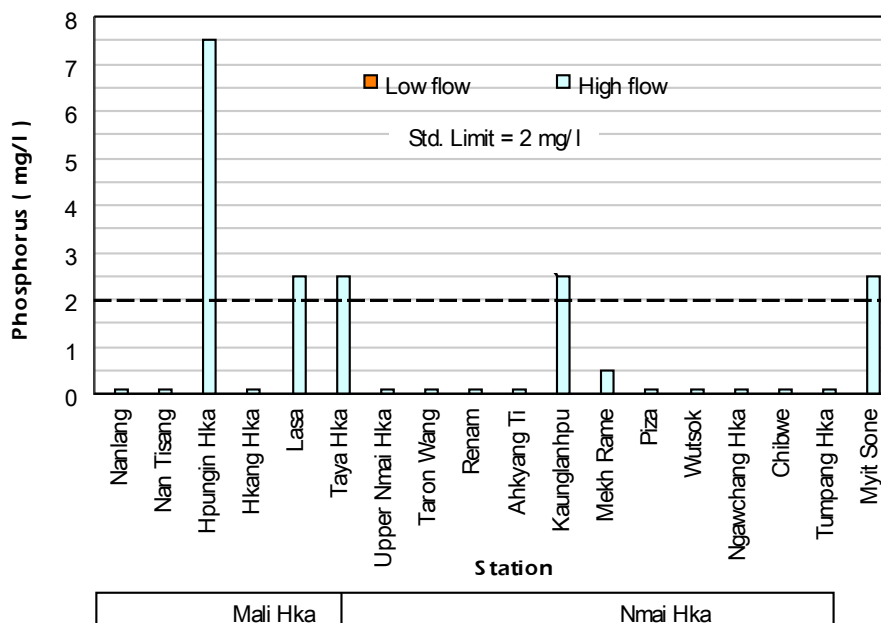
Phosphate are not toxic and do not represent a direct health threat to human and other organism but make a serious indirect threat to water quality. Phosphate can also interfere with water treatment processes. Concentrations as low as 0.2 mg/l interfere with the chemical coagulations or turbidity.

The phosphorus is an essential constituent in all living organisms. It plays an important part in cellular reproduction and contributes to the transfer of energy in respiration and photosynthesis process. An acceleration in the rate of additions of plant nutrients, such as phosphorus to natural water results in increased biological populations and production. This process known as eutrophication, occurs both naturally and as a result

of waste disposal and land use practices. Suspended algae in open waters and attached algae on the bottoms of shallow waters are part of the eutrophication processes in lakes.

The collected sample was preserved by adding 1 ml 30% H_2SO_4 in 100 ml of water.

Fig. 7.10 Phosphorus of Surface Water



Findings

The Phosphorus level in surface water at high flow period at Myitsone, Hpungin Hka, Lasa, Kaunglanhpu and Taya Hka is higher than the standard limit (2.0 mg/l). This might be due to plants and animal tissue and runoff from the agricultural areas near the station and shifting cultivation of remote area.

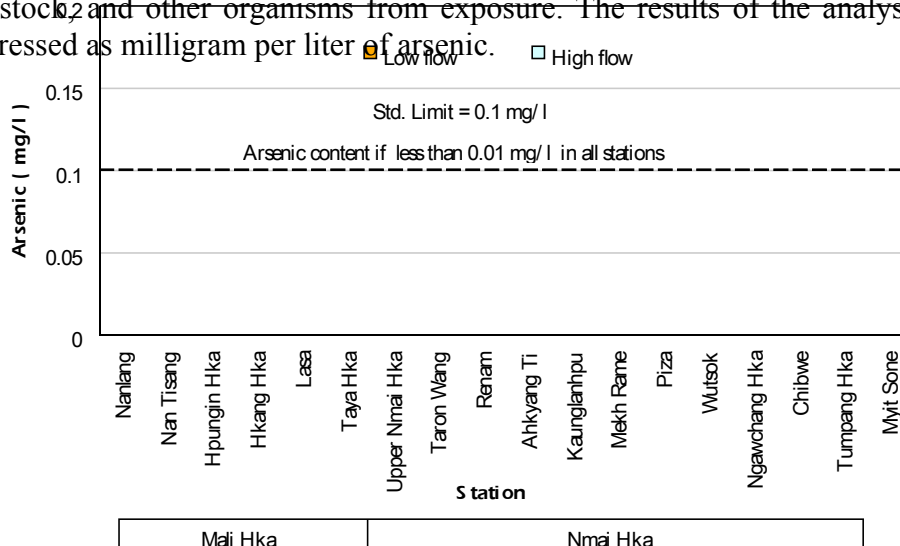
5.2.11. Arsenic (As)

Arsenic occurs widely in the natural environment. The highest mineral concentrations can be found as arsenides or copper, lead, silver and gold, but the high levels may also be found in some coal. The principal natural sources of arsenic in the atmosphere are volcanic activity.

Arsenic can have both active and chronic toxic effect on humans. It affects many organ systems including the respiratory, gastrointestinal, cardiovascular, nervous and hematopoietic systems.

Fig. 7.11 Arsenic of Surface Water

Ambient standards and guidelines for arsenic are aimed at protecting the population, livestock and other organisms from exposure. The results of the analysis are usually expressed as milligram per liter of arsenic.



Findings

The results of analysis of arsenic both in low flow and high flow in all areas was found to be less than 0.01 mg/l on average in the area at the present. Allowable arsenic limit is 0.1 mg/l and hence no problem of arsenic was found in the area.

5.2.12. Chromium (Cr)

Chromium is an element naturally found in rocks, animals, plants and soil. Chromic and chromate ions are toxic to plants.

The chromium can be found in air, soil and water after disposal of chromium based products during the manufacturing processes. The chromium does not usually remain in the atmosphere, but is deposited in the soil and water. The chromium moved from one place to another in water and soil. The chromium is occasionally detected in ground water, drinking water or soil samples. The collected sample was added with 2 ml concentrate HNO_3 /l of water for preservation.

The same water course may have quite a different water quality at the same measuring point due to the different mutual effects between the river water and ground water. The high water levels result in the infiltration of river water into the aquifer while low water levels may lead to ground water depletion.

The International Agency for Research on Cancer (IARC) has determined that chromium compounds are carcinogenic to humans. The workers whose inhalation composed of chromium have been found the trace of lung cancer. And stomach tumors was observed in humans who exposed to chromium in drinking water. Chromium compounds have been found to cause tumors to the stomach, intestinal tract and lung.

A small percentage of ingested chromium will enter the body through the digestive tract. The chromium is a component of tobacco smoke. The smoking should be in enclosed spaces like inside the room or car in order to limit exposure to children and other family members. The chromium is required as a nutrient in the body. It is normally present in food, in blood, urine and body tissues.

The collected sample was preserved by adding 2ml concentrated HNO_3 /l of water.

Fig. 7.12 Interactions between ground water and a river

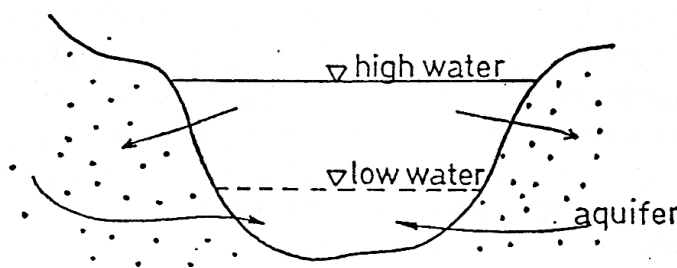
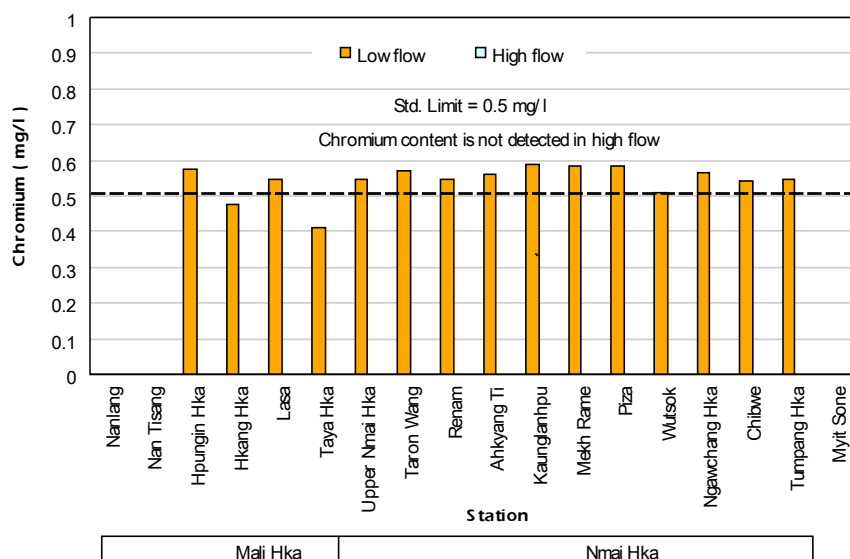


Fig. 7.13 Chromium of Surface Water



Findings

At low flow chromium in the surface water of most of the station observed was found slightly higher than the standard limit of 0.5 mg/l. But at high flow chromium was not detected. There is no problem of chromium in this region at present.

The chromium does not usually remain in the atmosphere but is deposited into the soil and water. The chromium in surface water was found in most of the area. At low flow it was slightly higher than standard limit of 0.5 mg/l. But it was not detected for all sites at high flow period.

The chromium in surface water found at low flow may be due to coming up of ground water seepage flow that contain chromium into the river. Geological investigation of the ground water containing chromium content in the upstream is necessary for future monitoring of the area.

5.2.13. Mercury (Hg)

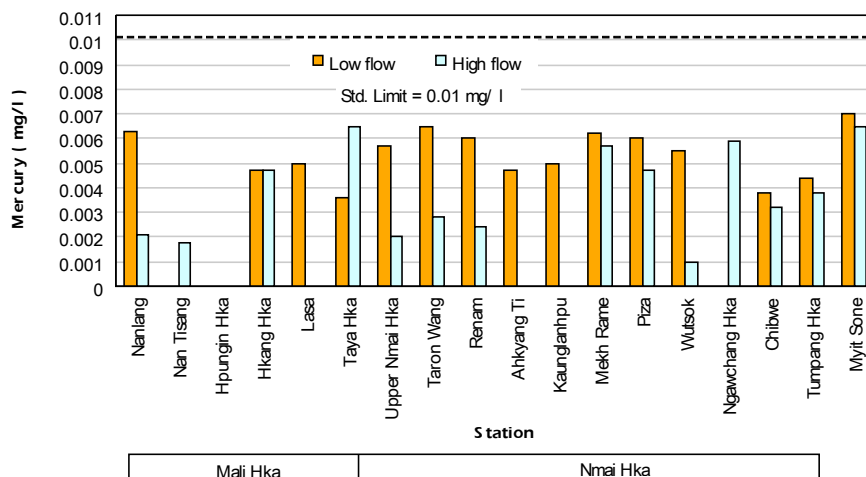
Mercury is a toxic heavy metal found in Mercuric sulfide and other ores compounds consisting of zinc, tin, and copper; in rocks such as limestone, sandstone, calcareous shale, and basalt, and in fossil fuels such as coal. Mercury can be traced in all environmental media. Typical concentration of mercury in water bodies range from 0.001 to 0.003 micrograms per litre (mg/l). The mercury enters into the environment through disposal of certain products.

The main human health hazard of mercury is associated with exposure to highly toxic organic methyl mercury, primarily through the ingestion of aquatic organisms. Mercury is also highly toxic to animals. Mercury compounds could be retained in tissues for an extended period.

Methyl mercury poisoning affects the central nervous system and the area associated with the sensory, visual, auditory and coordinating functions. Mercuric sulfide is highly

toxic to human through ingestion or inhalation of dust and it causes both chronic and acute poisoning. The collected sample was preserved by treating with HNO_3 to reduce the $\text{pH} < 2.0$.

Fig. 7.14 Mercury of Surface Water



Findings

Limit of mercury in surface water for general application is 0.01 mg/l. Results of investigation show that Mercury level is less than standard limit at both flow and high flow situation. At present there is no mercury problem detected in the investigated area.

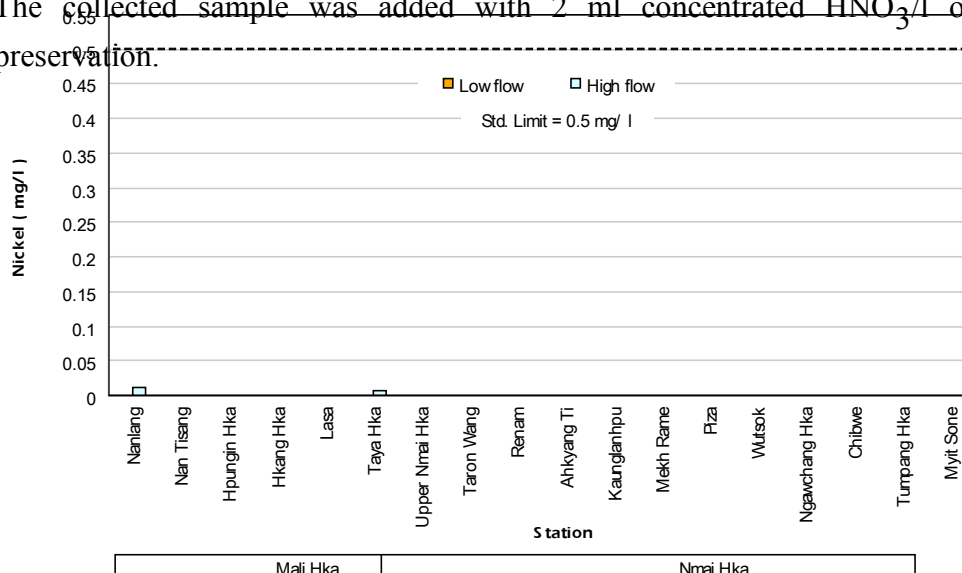
There are many gold mines along the river. The mercury can be deposited at the bottom of the rivers. Further investigation is necessary to analyze the water not only at surface but also at bottom layer. Mercury is heavy metal and hence traces of it may be found at the bottom.

5.2.14. Nickel (Ni)

Nickel is similar to the these elements, chromium, alluminium and titanium. Nickel is a very reactive element but is slow to react in air at normal temperatures. High level or low level of nickel can be toxic, especially if associated with high exchangeable Mg:Ca ratios. Nickel sulphide fume and dust is believed to be carcinogenic. The various other nickel compounds may also be the same affect as well. Nickel is an important cause of contact allergy, partly due to its use in jewellery for pierced ears. Limit of Nickel in surface water for general application is 0.5 mg/l.

Fig. 7.15 Nickel of Surface Water

The collected sample was added with 2 ml concentrated HNO_3 of water for preservation.



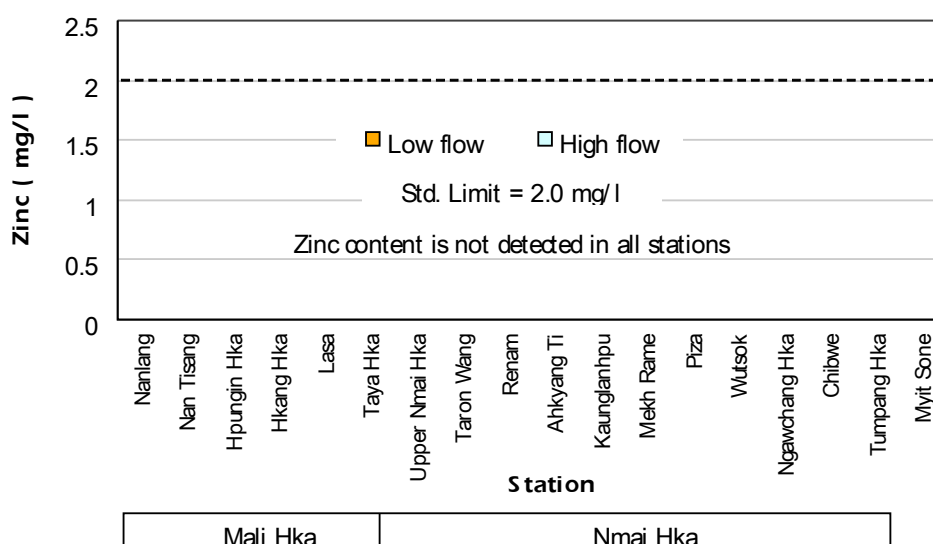
Findings

At present nickel in surface water in all areas was found below the limit of 0.5 mg/l although two stations ,Nanlang and Taya Hka, have Nickel content of less than 0.01mg/l and hence no danger to the region at present.

5.2.15. Zinc (Zn)

Zinc is highly abundant in nature. Zinc ions are readily contained in the sediment particles. Zinc is an essential mineral for the human health and biological environment. Although Zinc is and an essential requirement for good health, excess Zinc can be harmful. It can be chronically and acutely toxic to aquatic organisms especially fish. The bottles were rinsed with nitric acid (1:1 with distilled deionized water). The collected sample was added with 2 ml concentrated HNO_3 /l of water sample for preservation.

Fig. 7.16 Zinc of Surface Water



Findings

Zinc content in surface water at all stations was found to be less than 1.0 mg/l. The study area has no problem of Zinc at present. Zinc is heavy metal which can be

deposited at the bottom. Further investigation is necessary to determine the water quality according to depth.

5.2.16. Particulate matter

Most Particulate Matter such as smoke, soot or dust are easily visible but others are not. The particulates include materials such as airborne asbestos particles and small particles of heavy metals such as arsenic, copper, lead and zinc. They are usually emitted from industrial facilities such as smelters. The most significant of the fine particulate pollutants are sulphates and nitrates. These may combine with water vapor to form sulphuric and nitric acid. The particulate matter is often referred to as total suspended particulate (TSP).

Particulates may effect the human health, natural ecosystems and also to the biosphere. Particulates that enter the lungs may lodge there and have chronic effects on respiration. Dust from road construction may spread and deposited on the surfaces of green plants and interfere with their absorption of carbon dioxide and oxygen. Heavy dust may also affect the breathing of animals.

Finding

Particulate matter of all stations was found between 0.03 to 2.08 $\mu\text{g}/\text{m}^3$ except at Myitkyina which was under the 70 $\mu\text{g}/\text{m}^3$, limit of particulate matter for maximum 24 hour average.

5.2.17. Sulphur dioxide

This heavy, pungent, colorless, gaseous air pollutant are formed primarily by processes involving fossil fuel combustion.

Sulphur dioxide is a colourless and odorless gas under normal conditions at Earth's surface. The major sources for the anthropogenic component of sulphur dioxide is burning of fossil fuels, mostly coal in power plants. Another major sources is a variety of industrial processes ranging from refining of petroleum to production of paper, cement etc. Corrosion of paint and metal smoke cause injury or death to plants and animals, especially to crops such as alfalfa, cotton and barley. Sulphur dioxide particularly in the sulphate form is capable of causing severe damage to lungs of human and other animals.

Findings

Sulphur dioxide in all stations was found between 0.06 to 0.79 $\mu\text{g}/\text{m}^3$. Limit of Sulphur dioxide for maximum 24 hour average is 125 micro gram per cubic meter.

5.3. Types and Effects of Water Pollution

Water pollution is any physical, biological, or chemical change in water quality that adversely affects living organisms. Water qualities are grouped according to the nature and findings and comments were outlined as follows.

(Ref. Water Pollution, Chapter 18, P. 380-395)

5.3.1. Acids and bases

pH values show Acid or Base. They are within limit at both flow condition.

Coal and oil combustion leads to formation of atmospheric sulfuric and nitric acids, which are disseminated by long-range transport processes and deposited via precipitation (acidic rain, snow, fog, or dry deposition) in surface waters. Meteorologists suggest that the cloud, 80% of which is made by human could disrupt monsoon weather patterns. They may effect the project area in future. Where soils are rich in such alkaline material as lime stone, these atmospheric acids have a little effect because they neutralized with alkaline. In high mountain areas or recently glaciated regions where crystalline bedrock is closed to the surface and lakes are oligotrophic, there is little buffering capacity (ability to neutralize acids) and aquatic ecosystems can be severely disrupted.

Some fish, amphibians, and sensitive aquatic insects are generally the first to be affected if acid levels in the water increases. If acidification is severe enough, aquatic life is limited to a few acid resistant species of mosses and fungi. Increased acidity may also result in leaching of toxic metals, especially aluminium, from soil and rocks, making water unfit for drinking or irrigation as well. Aquatic damage due to acid precipitation may sometimes occurred and care should be taken by monitoring pH value of the river water in the project area.

5.3.2. Oxygen-demanding wastes

BOD and COD are expressed for quality of surface water, including oxygen-demanding waste. They are within limit in all investigation sites at both flows.

The amount of oxygen dissolved in the surface water is a good indicator of water quality of which it supports the aquatic life. Water with an oxygen content above 6 parts per million (ppm) will support some fish and other forms of aquatic life. Water with oxygen level less than 2 ppm will support mainly worms, bacteria, fungi, and other detritus feeders and decomposers. Oxygen is added to water by diffusion from the air, especially in turbulent water and mixing rates are high at the rapid flow, and by photosynthesis of green plants, algae, and cyanobacteria. Oxygen is removed from water by respiration and chemical processes organisms that consume oxygen in the reservoir. The water quality should be in original state in as much as possible after the damming of the river concerned.

The effects of oxygen-demand on rivers depends great extent on the volume, flow, and temperature of the river water. Aeration occurs readily in a turbulent, rapid flowing water and leads to recover quickly from oxygen-depleting processes.

To keep the river clean, no pollution source should exist along the river or adjacent to the river. Aquatic organism in the upstream of the pollution source gets oxygen levels to support normal populations of clean-water organism. Immediately below the source of pollution, oxygen levels begin to fall as decomposers metabolize waste materials. Some fish species can only survive in this oxygen-poor environment where they eat both decomposer organisms and waste itself. Further downstream, the water may become so oxygen-depleted that only the most resistant microorganisms invertebrates can survive. Eventually, most of the nutrients are used up, decomposer populations are smaller, and the water becomes oxygenated once again. Depending on the volumes and flow rates of the effluent plume and the river receiving it, normal communities may not appear several miles downstream. So, pollution sources should be avoided in the vicinity of the project area.

5.3.3. Organic chemicals

Cyanide, Oil and Grease, and Phenol are organic chemicals. Content of Oil & Grease and Phenol at the observed stations are above the limit, and the remainings are below the limit.

Thousands of different natural and synthetic organic chemicals are used in the chemical industry to make pesticides, plastics, pharmaceuticals, pigments and other products that we used in every day life. Many of these chemicals are highly toxic. Exposure to very low concentrations (perhaps even parts per quadrillion in the case of dioxins) can causes birth defects, genetic disorders, and cancer. Some can persist in the environment because they are resistant to degradation and toxic to organisms that ingest them. Contamination of surface water and ground water by these chemicals is a serious threat to human health.

An example of the most important sources of toxic organic chemicals in water are improper use of fuel in machineries in gold mining and boats in river transportation, and decaying vegetation and plants in the forest. Much of these materials wash away into the nearest river, where it passes through ecosystem and may accumulate and severely affected the certain organism in the polluted water in surveying sites of the project.

5.3.4. Inorganic pollutants

Arsenic, Chromium, Mercury, Nickel and Zinc are inorganic pollutants. At the observed stations chromium content is higher above the permissible limit at low flow at all locations and within the limit at high flow.

Some toxic inorganic chemicals are released from rocks by weathering, percolating into ground water aquifers and then flowing into the river as seepage. This pattern is part of natural mineral cycles. But humans may accelerate the transfer rates in these cycles more through mining processing by using and discarding of minerals. That activities must be prohibited in the project area. In order to avoid the contamination of inorganic pollutants in the river, human activities that affect the environment should be minimize as much as possible.

In many areas, toxic, inorganic chemicals introduced into water as a result of human activities have become the most serious form of water pollution. Among the chemicals of greatest concern are heavy metals, such as mercury, lead, tin, and cadmium. Super toxic elements, such as selenium and arsenic, are more hazardous in waters. Although other inorganic materials, such as acids, salts, nitrates, and chlorine are not toxic normally at low concentrations it may adversely affect biological communities. When concentration is large, proper and good water quality should be maintained in the reservoir and river concerned. Further investigation of Mercury and Arsenic in river bed is required for the monitoring of the river. Present surface water surveying of that parameters is inadequate for water quality. Later monitoring of the river communities is required.

5.3.5. Sediments

Total Suspended Solids (TSS) are sediments and found above the limit at high flow at all the observed stations.

All the rivers have always carried sediments along its courses and finally to the oceans. Erosion rates in many areas have been greatly accelerated by human activities. Some rivers carry astounding loads of sediment. Erosion and runoff from croplands contribute about 25 billion metric tons of soil, sediments, and suspended solids to world surface waters each year. Forests, grazing lands, urban construction sites, and other sources of erosion and runoff add at least 50 billion additional tons. This sediment fills

lakes and reservoirs, obstructs shipping rivers, clogs hydroelectric turbines, and polluted the drinking water. Sediments smother gravel beds in which insects take refuge and fish lay their eggs. Suspended sediments particles in the water block sunlight so that plants cannot carry out photosynthesis in a declined oxygen levels. Murky, cloudy water also is less attractive for swimming, boating, fishing, and other recreational activities.

Gold mining in project area and construction of access roads for various purposes are one of the causes of much TSS above the limit in the study area. In other way, sediment also can be beneficial. Mud carried by rivers nourishes floodplain farm lands. Sediment deposited in the ocean at river mouth creates valuable and fertile deltas and islands. The Ganges River, for instance, builds up islands in the Bay of Bengal that are eagerly colonized by land-hungry people of Bangladesh. Louisiana's muddy Mississippi serves to counteract coastal erosion. Thus sediments are pollutants for some way, while valuable in another for agriculture, erosion protection and food web for the project area.

5.3.6. Thermal pollution and thermal shocks

Raising or lowering water temperatures from normal levels can adversely affect water quality and aquatic life that depends upon it.

Water temperatures are usually much more stable than air temperatures. Raising water temperatures can have similar devastating effects on sensitive organisms. Oxygen solubility in water decreases as temperatures increases, so species requiring high oxygen levels are adversely affected by warming water.

Some human activities such as altering vegetation cover and runoff patterns along the river system may cause thermal pollution. To avoid sudden rising or lowering of water temperature in biological communities, strategic location and construction of series of dam and reservoir is an important factor for pollution control of the river system.

5.3.7. Plant nutrients and cultural eutrophication

Nitrogen and Phosphorus are major indicator of plant nutrients at the observed stations. The former is above the limit at both flow and the latter is above the limit at high flow in some locations.

Water clarity (transparency) depend on the sediments, chemicals, and the abundance of plankton organisms, and is a useful measure of water quality. Rivers and lakes that have clear water and low biological productivity are said to be oligotrophic (oligo=little+trophic=nutrition). By contrast, eutrophic (eu+trophic=truly nourished) waters are rich in organisms and organic materials. Eutrophication is an increase in nutrient levels and biological productivity. Some amount of eutrophication is a normal part of successional changes in most lakes. Tributary streams bring sediments and nutrients that stimulate plant growth. Over time, most ponds or lakes tend to fill in and eventually become marshes. The rate of eutrophication and succession depends on water chemistry, depth, volume of inflow, mineral content of the surrounding watershed, and the biota of the lake itself.

Human activities can greatly accelerate eutrophication. An increase in biological productivity and ecosystem succession caused by human activities is called cultural eutrophication. Cultural eutrophication can result from increased nutrient flows, higher temperatures, more sunlight reaching the water surface, or a number of other changes. Increased productivity in an aquatic system sometimes can be beneficial. Fish and other species may grow faster, providing a food web in the river ecosystem.

However, eutrophication has undesirable results. Increased phosphorus and nitrogen levels stimulate "blooms" of algae or thick growths of aquatic plants. Bacterial

populations also increase and they are fed by larger amounts of organic matter. The water often becomes cloudy or turbid and has unpleasant tastes and odors. In extreme cases, plants and algae die and decomposers deplete oxygen in the water. Collapse of the aquatic ecosystem can result in some place of reservoirs in the project area. Systematic reservoir operation and maintenance is required to keep the nutrient level acceptable for a balanced environment of the river.

5.3.8. Water pollution control

We have a chance to control water pollution and improve water quality. We can plan in advance environmentally friendly project without ecological degradation. Appropriate land-use practices and proper disposal of different pollutants and waste coming from industries, domestic use and agriculture are required for control of water pollution.

Reduction of point pollution

The cheapest and most effective way to reduce pollution in the first place is to avoid producing it at all or avoid releasing it to the environment.

Careful handling of oil and petroleum products can greatly reduce the amount of water pollution caused by these materials to the environment.

Reduction of non-point pollution and land management

Among the greatest remaining challenges in water pollution control are diffuse and non-point pollution sources. Unlike point sources, non-points sources have many origins and numerous routes by which contaminants enter the ground and seep into river waters. It is difficult to identify all these sources and routes in some cases. Some main sources of non-point pollution may be :

- Construction sites : New buildings and infrastructures, improper land development works and occasional land slide which affect the adjacent small areas but produce vast amounts of sediment to that area.
- Land disposal : Land disposal of certain kinds of waste, sewage sludge, and biodegradable vegetables should be done carefully to dispose of unwanted materials. At some poorly run land disposal sites, abandoned dumps, and leaking septic water systems lead to contaminate the surface waters of the project area.

Generally, soil conservation methods can also help protect water quality. Precise monitoring and managing of oil, grease, and pesticides saves money and reduces contaminants entering into the reservoirs and rivers in the project area.

5.4. Monitoring of Ambient Air Quality

Monitoring is limited to some key pollutants such as suspended particulate matter (SPM). A good air quality management system usually reviews the probable emission sources and environmental receptors in the area concerned and then selects the pollutants to be monitored. One such pollutant is particulate matter of less than 10 microcons in aerodynamic diameter (PM_{10}). Other pollutants normally monitored included Sulphur Dioxide (SO_2).

The particulate matter (PM_{10}) and Sulphur Dioxide (SO_2) test were done in low flow period. The samples were analyzed at Toxicology and Environment at Health Laboratory, Department of Health in Yangon. The results are shown the Table 24.

Ambient air conditions at study areas and particulate matter concentrations are below the limit of 70 micro grams per cubic meter at maximum 24 hour average.

Findings

Pilot test of particulate matter at Myitkyina Camp is 269.87 microgram per cubic meter. Ambient air conditions at all study areas, and Sulphur Dioxide concentration are much lower than below, the limit of 70 micrograms per cubic meter at maximum 24 hour average.

Table 24. Monitoring of Ambient Air and Acoustic Environment

Sr. No.	Location (Monitoring Site)	Unit	TSP (PM ₁₀)	SO ₂	Remarks
1	Myitsone	µg/m ³	2.08	0.33	
2	Lasa	µg/m ³	0.07	x	
3	Chibwe	µg/m ³	0.23	0.13	
4	Wutsok	µg/m ³	0.47	0.08	
5	Piza	µg/m ³	0.13	0.79	
6	Kaunglanhpu	µg/m ³	1.53	0.06	
7	Yenan	µg/m ³	x	x	
8	Kaunglanhpu	µg/m ³	x	x	
9	ManKyi	µg/m ³	0.18	0.18	
10	Tasawlaw	µg/m ³	x	x	
11	Sawan	µg/m ³	x	x	
12	Acess Road	µg/m ³	x	x	
13	Infega	µg/m ³	0.46	0.53	
14	Putao	µg/m ³	0.03	0.03	
15	Myintkyina	µg/m ³	269.87	0.41	

Investigation of Air pollution and sound pollution were done at Myintkyina, Infega, Putao as pilot tests.

x Most of the tests are quite acceptable except for a few dusts.

- Particulate matter of all stations was found between 0.03 to 2.08 µg/m³ except at Myintkyina station.
- Limit of particulate matter for maximum 24 hour average is 70 µg/m³.
- Sulphur dioxide in all stations was found between 0.06 to 0.79 µg/m³.
- Limit of sulphur dioxide for maximum 24 hour average is 125 µg/m³.

5.4.1. Control of air pollution

The following methods are most effective for dealing with the control of air pollution.

- (a) Source Correction Methods (c) Diffusion of pollutant in air. (e) Zoning
(b) Pollution Control equipment. (d) Vegetation.

5.5. Monitoring of Acoustic Environment

Noise abatement measures should achieve either the levels given below or a maximum increase in background levels of 3 decibels (Measured on the A scale) [dB(A)]. Measurements were made at the dam sites of the proposed hydropower stations and

other places, totaling 7 monitoring sites, using TES sound level meter model TES -1350A.

Table 25.

measurement	Maximum allowable sound level hourly by log equivalent in dB(A)	
	Day	Night
	(07.00 -22.00)	(22.00 -07.00)
Receptor Residential,		
Institutional, educational	55	45
Industrial, commercial	70	70

The results are shown in the following Table 26.

Table 26. Acoustic Environment Monitoring

Sr. No.	Location (monitoring site)	Sound Pressure Level (A-weighted) dB (A)	
		Day (07:00 - 22:00)	Night (22:00 - 07:00)
		Leq	Leq
1	Lasa	83.08	79.50
2	Chibwe (Dam Site)	99.74	91.24
3	Wutsok	100.40	110.42
4	Piza	55.16	-
5	Kaunglanhpu	4.51	-
6	Yenam	92.91	90.76
7	Mankyi	113.14	96.70

The sound level at Kaunglanhpu and Piza station was found between 4.51 to 55.16 dB (A). The sound level at remaining stations are higher than the limit due to the cascades.

5.5.1. Control of acoustic pollution

From the above discussion, it is evident that noise is not merely a nuisance but is a serious environmental problem and a health hazard. Like all other pollutions, noise pollution needs to be controlled by measures which will maintain the acceptable levels of noise pollution for human beings and buildings as indicated in the Para-5.5.

Noise pollution can be effectively controlled by taking the following measures:

- (a) Control at Receiver's End (d) Sound Insulation at Construction Stages
- (b) Suppression of Noise at Source (e) Planting of Trees
- (c) Acoustic Zoning (f) Legislative Measures

5.6. Investigation of Pollution Sources

5.6.1. Investigation of effluent outlet

For investigation of the main effluent outlets of the main stream and key branches of Nmai Hka River and of Mali Hka River, main pollutions tests were done in low-flow period from January 2009 to March 2009.

Total suspended solids (TSS) in Ngawchang Hka site was found to be 250 mg/l. The standard limit of surface water for general application is 50.0 mg/l. The limit of TSS water is 100 mg/l. TSS in all sites was found lower than the above limits except Ngawchang Hka site.

Turbidity in Mekh Rame, Ngawchang Hka, Hpungin Hka and Toron Wang was found very much higher than the limit. The turbidity limit of WHO drinking water standards is between 5.0 to 25.0 J.T.U.

Total dissolved solids (TDS) in all observed sites was found between 17.92 to 87.04 mg/l. These are very much lower than the limit of WHO standard (500 mg/l).

Alkalinity in observed sites was found between 40 to 80 mg/l. The maximum levels of alkalinity have not been set by the EPA for drinking water or wastewater discharges (Water Pollution . Page -19).

Hardness in all observed stations was found between 25.0 to 40.0 mg/l. The public Health Service Standard recommend a maximum of 500 mg/l of hardness in drinking water. A maximum limit is not set by the EPA Standards (Water Pollution , Page -21). The results are very much lower than the EPA Standards.

Water pollutants such as Zn, As, CN, BOD and COD in all sites were found as the negligible amount in water.

Pesticides were not detected as the observed data is less than 0.01 mg/l (LOD).

Chromium in all sites was found to be less than the limit of 0.5 mg/l.

Nitrogen in all observed stations was found to be between 14.0 and 33.6 mg/l. These are higher than the limit of general application (10.0 mg/l). But according to the drinking water standard of WHO, the results are lower than for both of the highest desirable limit and the maximum permissible limit which is 45 mg/l.

Phosphorus in all observed stations was found less than 0.50 mg/l. Phosphorus of general application limit is 2.0 mg/l. There is no problem of phosphorus at present.

Pesticides in all observed sites were not detected in general and found to be less than 0.01 mg/l(LOD).

The detailed results of specific pollutants are described in the following Table 27.

Table 27. Investigation of Effluent Outlet

Sr. No	Effluent Outlet location	Waste Water Discharge Amount	Pollutant Type	Discharge mode	Time interval	Discharging where about
1	Ahkyang Ti	River & Tributary discharge	Water Pollution	River & Tributary Flow	River continual flow	Nmai Hka
2	Mekh Rame	"	"	"	"	"
3	Ngawchang Hka	"	"	"	"	"
4	Tumpang Hka	"	"	"	"	"
5	Nan Lang	"	"	"	"	Mali Hka
6	Nan Tisang	"	"	"	"	"
7	Hpungin Hka	"	"	"	"	"
8	Hknang Hka	"	"	"	"	"
9	Taron Wang	"	"	"	"	"
10	Upper Nmai Hka	"	"	"	"	Nmai Hka
11	Taya Hka	"	"	"	"	"

Sr. No	Effluent Outlet location	Concentration Unit																
		TSS mg/l	Tur NTU	Tem A °c	Tem B °c	TDS mg/l	Alk mg/l	Hard g/l	Zn mg/l	As mg/l	CN mg/l	BOD mg/l	COD mg/l	Hg mg/l	N mg/l	P mg/l	Pes mg/l	Cr mg/l
1	Ahkyang Ti	5	0	30.2	16.10	33.28	108.02	48	<1	<0.01	<0.1	N.D	N.D	0.0047	19.6	<0.50	N.D	0.56
2	Mekh Rame	15	43	30.7	15.90	23.68	61.01	72	<1	<0.01	<0.1	N.D	N.D	0.0062	19.6	<0.51	N.D	0.585
3	Ngawchang Hka	250	116	30.7	24.80	40.95	120.02	44	<1	<0.01	<0.1	0.4	N.D	0.0000	22.4	<0.52	N.D	0.565
4	Tumpang Hka	<5	3	30.3	21.80	30.08	80.01	34	<1	<0.01	<0.1	0.6	2	0.0044	33.6	<0.53	N.D	0.548
5	Nan Lang	<5	2	29.7	18.90	53.76	120.00	52	<1	<0.01	<0.1	N.D	N.D	0.0063	31.4	<0.54	N.D	N.D
6	Nan Tisang	<5	1	27.9	18.00	17.92	60.00	20	<1	<0.01	<0.1	N.D	N.D	0.0000	20.4	<0.55	N.D	N.D
7	Hpungin Hka	5	122	31.2	22.40	51.20	80.01	44	<1	<0.01	<0.1	N.D	2	0.0000	16.8	<0.56	N.D	0.575
8	Hknang Hka	<5	2	29.7	21.70	32.00	80.00	28	<1	<0.01	<0.1	0.2	2	0.0047	33.6	<0.57	N.D	0.477
9	Taron Wang	<5	83	31.0	20.64	44.16	80.01	46	<1	<0.01	<0.1	0.2	N.D	0.0065	22.6	<0.58	N.D	0.572
10	Upper Nmai Hka	<5	1	30.5	11.40	47.36	80.01	44	<1	<0.01	<0.1	0.6	N.D	0.0057	14	<0.59	N.D	0.549
11	Taya Hka	<5	2	29.8	27.90	87.04	120.00	72	<1	<0.01	<0.1	0.2	4	0.0036	28	<0.60	N.D	0.413

5.6.2. Investigation of pollution source

Total suspended solids (TSS) in all observed sites was found to be less than 5.0 mg/l. These are lower than the standard limit (50 mg/l).

Turbidity in Chibwe site was found 98.0 NTU. According to WHO and drinking water standard highest desirable limit is 5.0 and maximum permissible limit is 25.0 JTU.

Total dissolved solids (TDS) in all observed sites was found between 33.92 to 34.90 mg/l. These are lower than the limit of WHO standards (500 mg/l).

Alkalinity in all observed sites was found between 60.0 and 120.02 mg/l. The maximum levels of alkalinity have not been set by EPA for drinking water or wastewater discharges (Water Pollution , Page -19).

Hardness in all observed stations was found between 20.0 and 52.0 mg/l. The Public Health Service standards recommend a maximum of 500 mg/l of hardness in drinking water. A maximum limit is not set by the EPA standards (Water Pollution , Page -21). These are very much lower than the EPA standard.

Water pollutants such as Zn, As, CN, BOD, COD and Hg in all observed stations were not detected in general and the amount of concentration in the water is negligible at present.

Nitrogen in all observed stations was found to be between 14.0 and 33.6 mg/l. These are higher than the limit of general application (10.0 mg/l).

Phosphorus in all observed stations was found to be less than 0.50 mg/l. Phosphorus limit of general application is 2.0 mg/l. There is no problem of phosphorus at present.

Pesticides were not detected in all observed stations. It was less than 0.01 mg/l (limit of detection)

Chromium in all observed sites were found slightly higher than the standard limit of 0.5 mg/l, except Nan Lang and Nam Tisang. The chromium in Nan Lang and Nam Tisang was not detected at present.

Investigation of pollution sources in large towns include Putao, Nanghkai , Machanbow and Chibwe. At present no serious problems on industrial pollution sources and domestic pollution sources are found. Pollution of stream water as well as waste water have been analyzed. Concentration of these pollutants were indicated in the Table 28.

Table 28. Investigation of Pollution Sources

Sr. No.	Distribution Location of Pollution Sources	The Pollution Sources	Nature of Business	Product Name	Product Output	Waste Water Amount	Existing Waste Water Treatment Facilities	Treatment Technology	Method and Effect
1	Putao	Domestic	Nil	Nil	Low Flow	Discharge	Nil	Nil	Nil
2	Nong Hkai	"	"	"	"	"	"	"	"
3	Machanbaw	"	"	"	"	"	"	"	"
4	Chibwe	"	"	"	"	"	"	"	"

No.	Distrib. Locat. of Pollut. Sources	Type of Wast Water Produce																
		TSS mg/l	Tur NTU	Tem A °c	Tem B °c	TDS mg/l	Alk mg/l	Hard mg/l	Znm g/l	As mg/l	CN mg/l	BOD mg/l	CO D mg/l	Hg mg/l	N mg/l	P mg/l	Pes mg/l	Cr mg/l
1	Putao	<5	2	29.0	20.0	34.9	50	25	<1	<.01	<0.1	N.D	N.D	0.0	19.0	<0.5	N.D	0.40
2	Nong Hkai	<5	1	29.7	19.0	34.56	40	28	<1	<.01	<0.1	N.D	2.0	0.0	19.6	<0.5	N.D	0.40

3	Machan baw	<5	1	29.6	18.9	34.00	40	27	<1	<.01	<0.1	N.D	2.0	0.0	19.5	<0.5	N.D	0.4
4	Chibwe	<5	98	30.3	23.5	33.92	80	40	<1	<.01	<0.1	0.20	N.D	3.8	19.6	<0.5	N.D	0.5

5.6.3. Investigation of non-point pollution source

Investigation and estimation of the non-point pollution source indexes of Nmai Hka River, Mali Hka River and their main tributaries were carried out. Pollutants include Phosphorus, Nitrogen, Chemical Oxygen Demand, Ammonia, Pesticides and Chemical Fertilizers. These are shown in the following Table 29.

- Chemical Oxygen Demand (COD) in Lasa, Tumpang Hka, Hpungin Hka and Hknang Hka sites was found to be 2.00 mg/l. COD in the remaining sites was not detected at present. These are less than the standard.
- Pesticides include Malathion, Chlorpyrifos, Diazinon, Fenitrothion, Diamethorate, Dichlorvos, Methomyl and Trizophos. These pesticides were not detected at present.
- Nitrogen in all observed stations was found to be between 14.0 and 33.6 mg/l. These are higher than the limit of general application which is (10.0 mg/l).
- Phosphorus in all observed stations was found to be less than 0.50 mg/l. Phosphorus of general application limit is 2.0 mg/l. There is no problem of phosphate at present.

The results are lower than for both of the highest desirable limit and maximum permissible limit, which is 45 mg/l.

Table 29. Investigation of Non-Point Pollution Sources

Sr. No.	Non-Point Pollution Source Indexes	COD	Pesticide	Chemical Fertilizer	
		mg/l	mg/l	N (mg/l)	P(mg/l)
1	Lasa	2.00	N.D	19.6	<0.50
2	Chibwe	N.D	N.D	19.6	<0.50
3	Ahkyang Ti	N.D	N.D	19.6	<0.50
4	Mekh Rame	N.D	N.D	19.6	<0.50
5	Ngawchang Hka	N.D	N.D	22.4	<0.50
6	Tumpang Hka	2.00	N.D	33.6	<0.50
7	Nan Lang	N.D	N.D	31.4	<0.50
8	Nan Tisang	N.D	N.D	20.4	<0.50
9	Hpungin Hka	2.00	N.D	16.8	<0.50
10	Hknang Hka	2.00	N.D	33.6	<0.50
11	Toron Wang	N.D	N.D	22.6	<0.50
12	Upper Nmai Hka	N.D	N.D	14.0	<0.50

Note

Pesticides

- | | |
|------------------|-----------------|
| (a) Malathion | (e) Diamethoate |
| (b) Chlorpyrifos | (f) Dichlorvos |
| (c) Diazinon | (g) Methomyl |
| (d) Fenitrothion | (h) Trizophos |

Pesticides - N.D = Not Detected < 0.01 ppm. LOD = Limit of Detection

6. POTENTIAL IMPACTS

6.1. General

Due to the hydropower project, there would be both positive and negative impacts on the environment. The electricity generated would help industrial developments, and would raise the standard of living of the people which accordingly would make the nation's economy higher. In dry season, the reservoir will help navigation and irrigation at the downstream. On the other hand there may be adverse impacts. Since the project is a gigantic one harnessing the lifeblood river of the country, it is very important to seriously study the possible adverse impacts. In this section, adverse impacts on the baseline studies are mainly forecasted so that mitigation measures could be considered for sustainable development. The forecasts are based on the research works and experiences of similar projects.

6.2. Impacts due to Fragmentation of River

The project is formulated to produce hydropower by building a series of cascade dams on Nmai Hka, Mali Hka and just at the downstream of the confluence of those two rivers. This causes fragmentation of river ecosystems which affects the physical variables such as flow regime and water quality and productivity and composition of species. Within a basin, the greater the number of dams, the greater the fragmentation of river ecosystems.

By adding large dams to a river systems it will result in an increased and cumulative loss of natural resources, habitat quality, environmental sustainability, and ecosystem integrity.

6.3. Impacts on Water Quality

The flowing water becomes stagnant due to impounding by a dam which makes many changes in water quality such as oxygen level, dissolved gases, temperature, chemistry, etc. Water quality parameters recover only slowly when water is released from a dam. Oxygen level may recover within one or two kilometers while temperature changes may still exist 100 km downstream. Where the distance between dams does not allow recovery to natural level, the biology of species at many hundreds of kilometers of river may be affected.

A dam would receive water that is already high in total dissolved gases as a result of upstream dam. Before the levels can be recovered to natural values, if the water from that dam is released or spilled, the problem would be passed on to further downstream which may make impacts on downstream ecosystem and biodiversity.

6.4. Altered Downstream Flow and Sediment Movement

Due to dam built on the river, storage volume is increased and it clearly affects the flood regime at downstream. Flood flows downstream would be significantly reduced. The positive impact of flood reduction is lessening of flood risk at the downstream areas. But flood plains which are habitat of some fauna and flora will disappear. Flood timing, duration and frequency will be completely changed. Complex biological communities

at the downstream will not be sustainable due to stable flows and conditions of regulated flow. Besides, natural fertilization of farm land carried by the flood will be lost. Reduction in sediment moving downstream from the dam leads to degradation of the river channel which may result in elimination of bars/banks, riparian vegetation that provides nutrients and habitat for aquatic and waterfowl species. Reduction in sediment input, results in degradation of coastal deltas. It is one of the most severe impacts because it threatens the formation of fertile land. This impact must be seriously considered since some already built dams are being decommissioned to avoid this adverse impact.

6.5. Erosion

The most likely damage to the watershed area may be due to deforestation for the construction sites, roads and wood requirements which may result in soil erosion problems and the destruction of the natural protection of the ground. The erosion of watershed areas would make the reservoir life shorter through the deposition of sediments while erosion along-side of river will create instability of river bank and accordingly affects the water quality.

6.6. Ambient Air

Previously it is conventionally accepted that hydropower produces only positive atmospheric effects such as a reduction in emissions of carbon dioxides, nitrous oxides, sulphuric oxides and particulates when compared with power generation sources that burn fossil fuels. But recent research identified that the emission of greenhouse gases (GHG) from reservoirs due to rotting vegetation and carbon inflows from the catchment creates an ecosystem impact which may account for 1 to 28 % of the global warming potential of GHG emissions.

There would be no difference in air pollution such as particulate matter (PM_{10}) and Sulphur dioxide with or without hydropower project situations. But during the construction period, air pollution would be affected due to construction equipment which will emit other gases and make a lot of dust. The air pollutants affect plants by entering through stomata of leaf and destroy chlorophyll and photosynthesis while human respiratory system is affected causing serious health problem in the long term.

6.7. Acoustic Environment

The project area is not an industrialized one and at present there is no noise pollution to the environment. Noise can cause temporary or permanent hearing loss depending on the intensity and duration of sound level. The nature of hydropower plants is not noisy compared to diesel power plants and noise level is expected to be lower than 70 dB(A) Leq. But during construction period, significant noise pollution will be sensed at construction sites and along roads.

7. MITIGATION MEASURES

7.1. General

Some impacts of a hydropower project unavoidably have adverse effects on the ecosystem. To be a sustainable project, these adverse impacts should be mitigated or minimized or compensated by some means and measures. The possible mitigation

measures are discussed in this section and should seriously be considered in the design, implementation and operation works. Reference for monitoring and control of pollutance in reservoirs and rivers is shown in Appendix-3.

7.2. Watershed Protection

Watersheds are likely to be destroyed not only due to construction works but also due to migrated people who have lost their places because of inundation. Watersheds provides many ecosystems functions ranging from nutrient recycling, water purification to soil replenishment and flood control. So to keep healthy watersheds it is very important that they are always monitored and protected. Educating the local people on the importance of watershed and practicing strict law enforcement are effective means of watershed protection.

7.3. Compensation and Green Plan

As an alternative to mitigation, a compensatory approach could be suggested. Regulations should be set on replantation of forests flooded by reserving. We should learn lessons from the comprehensive "Green Plan" done in the Netherlands to protect the affected area. (Reference No.(8) p 540).

7.4. Control of Pollution in Reservoir and Rivers

The first step to control reservoir and river pollution is to carry out a regular monitoring with regard to the parameters as observed at the proposed dam sites. One of the control measures for reservoir pollution is diversion of nutrients, removing of pollutants and nutrients from waste waters and proper water shed management in the catchment area.

For the control of river pollution, the following approach should be followed.

1. The most usual approach for river pollution control is to lay down standards governing the stream water quality and effluents discharged into it. Streams are generally classified according to the major use to which they are likely to be put, i.e., drinking, fish culture, irrigation, bathing etc. Each use requires some minimum water quality for which the standards can be applied.
2. At the time of lean flow seasons, the pollutants are likely to be concentrated in greater quantities, which can be controlled by augmenting the flow of water in the river by extra discharge from the upper reservoir.
3. At certain times in dry season, when the self-purification capacity is reduced considerably, extra oxygen can be provided by artificial aeration at the desired points. However, this method is costly and less feasible, but can be applied in emergency situations.
4. All the waste waters entering into a river system should be allowed only after a proper treatment. This can reduce the pollution load to a desired level calculated on the basis of stream conditions.

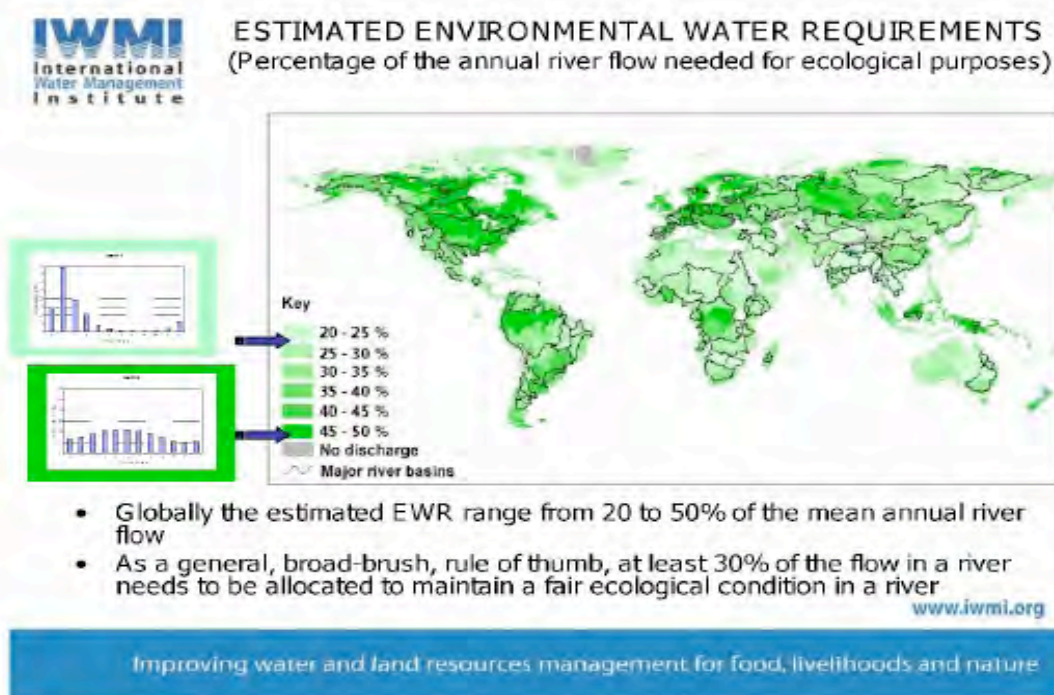
7.5. Flow Management

Since flow regime is totally disrupted due to the dam built on the river, the downstream flow should be regulated as similar as possible that of before the project. Operation programme should be planned to manage flood flow considering not only flood

alleviation and mitigation but also utilization of flood. Environmental flow requirement (EFR) must be considered in setting operation rule for the project.

As a rule of thumb for the environmental flow at the downstream of the dam after project completion the stream flow runoff should be 30% of annual runoff of the river (before the dam construction) in general when no reliable data for the evaluation of required environmental flow is available at present. (Ref: see table and map for world general environmental flow for different countries).

Fig. 8



7.6. Environmental Requirement Vs Water Resources Management

Since Ayeyarwady River is the lifeblood and main stream of Myanmar and Myanmar people, integrated water resources management of the uppermost Ayeyarwady River Basin, namely Nmai Hka River Basin and Mali Hka River Basin is totally required in accordance with the environmental requirement of the nation as a whole.

According to the Environmental Management Classes (EMC) outlined by the International Water Management Institutes, we recommend the EMC Class where natural river ecosystem is moderately modified in which basic ecosystem functions are intact despite slight disruption/disturbance of habitats and dynamics of the biota.

Since water resources development scheme has yet to be implemented, slight changes in natural pristine condition or minor modification of in stream and riparian habitat is unavoidable. But multiple ecosystem disturbances associated with the building of dam must be avoided in as much as possible by proper management of the river ecosystem in both upstream and downstream of dam after project implementation.

7.7. Trapping Sediments and Nutrients Behind A Dam

The sediments and nutrients flowing along with water are trapped because of the dam built across the river which affects seriously the downstream flood plain, coastal delta

morphology and causes the loss of aquatic habitat. The facility such as bottom outlet can be provided at the structure to flush out sediments whenever feasible by managing flood releases and although this measure has some limitations it should be included in the operating programme.

7.8. Blocking Migration of Aquatic Organisms

Some river dwelling species have several migratory patterns. Dams are physical barrier which disrupt migration of species between upstream and downstream. To overcome this impact, fish passes should be provided wherever feasible for migration of aquatic species. To get appropriate fish passes, it should be tailored to specific sites and species.

7.9. Greenhouse Gas Emission

Table 30



ENVIRONMENTAL MANAGEMENT CLASSES (EMC)

TOTAL ENVIRONMENTAL REQUIREMENT DEPENDS UPON THE CATEGORY OF ENVIRONMENTAL PROTECTION – THE MORE PRISTINE THE DESIRED MANAGEMENT CLASS - THE HIGHER THE REQUIREMENT

EMC	ECOLOGICAL DESCRIPTION	MANAGEMENT PERSPECTIVE
A: Natural	Pristine condition or minor modification of in-stream and riparian habitat	Protected rivers and basins. Reserves and national parks. No new water projects allowed.
B: Slightly modified	Largely intact biodiversity and habitats despite water resources development and/or basin modifications.	Water supply schemes or irrigation development present or allowed.
C: Moderately modified	Habitats and dynamics of the biota have been disturbed, but basic ecosystem functions intact.	Multiple disturbances associated with the need for socio-economic development, e.g. dams, diversions, etc.
D: Largely modified	Large changes in natural habitat, biota and basic ecosystem functions have occurred. A clearly lower than expected species richness.	Significant and clearly visible disturbances associated with basin and water resources development, including dams, diversions, transfers, habitat modification and water quality degradation.
E: Seriously modified	Habitat diversity and availability have declined. A strikingly lower than expected species richness. Alien species invaded the ecosystem.	High human population density and extensive water resources exploitation.
F: Critically modified	Modifications have reached a critical level and ecosystem has been completely modified with almost total loss of natural habitat and biota.	Status is not acceptable. Management interventions are necessary to restore flow pattern, river habitats etc (if still possible / feasible).

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The emission of greenhouse gas will be minimum if the reservoir is small and deep. To lessen the rotting of vegetations, which causes more emission of GHG, all vegetation should be removed before inundation.

7.10. Selection of Alternative Dam Sites

As described in section 6.3, the recovery of water quality to natural level is influenced by the distance between the two adjacent dam on a river. To maintain the existing ecosystem as much as possible, this criteria should be considered in selection of dam sites. In dam site selection, alternative sites should be studied considering not only the structural aspect but from environmental aspects.

7.11. Erosion

To minimize erosion, it is very important not to disturb the natural vegetation cover around the project area and in the watershed area as described in section 7.2. During

construction period, it is required to give strict instructions to construction teams not to disturb the ground outside the construction zone.

7.12. Disposal of Waste Material

It is very normal that construction waste such as used oil, tyres, waste construction material, etc. are disposed to the specified area which causes much disturbance to natural environment. So to keep the natural environment undisturbed, it should be instructed to use the specified disposal area only.

7.13. Awareness of People

Some practical suggestions should be given to educate the people for their awareness on environmental conservation, such as how to reduce consumption, organize an environmental campaign, communicate effectively with the media and report to authorities concerned relating to the care of environment of people.

8.

CONCLUSION

After the agreement signing on 15 November 2008, the environment baseline team had prepared for its investigation works. According to the Terms of Reference of EIA prepared by CISPDR, the team has gone on field investigation from January, 2009 to March, 2009 for low flow and from June, 2009 to August, 2009 for high flow situations.

Water Quality

The investigations are made at 7 proposed hydropower stations and at 11 sections at tributaries. pH, Temperature, BOD, COD, TSS, Oil and Grease, Phenol, Cyanide, Nitrogen, Phosphorus, Arsenic, Chromium, Mercury, Nickel and Zinc are parameters investigated relating to water quality. TSS, Oil and Grease, Phenol, Nitrogen and Phosphorus are found to be higher than the limit proposed by "Pollution, Prevention and Abatement Hand book 1998 Toward Cleaner Production (The World Bank Group)" especially in the high flow period while the other parameters are found to be within limit.

Ambient Air

The ambient air quality was measured from January to March 2009 and found to be within the limit proposed by the above mentioned World Bank Group Hand book.

Acoustic Environment

Investigations are made for acoustic environment from January to March, 2009 at the proposed hydropower station sites. At all sites except in Pisa and KaunglanHpu the sound level was higher than allowable level 70 dB (A) due to the cascades.

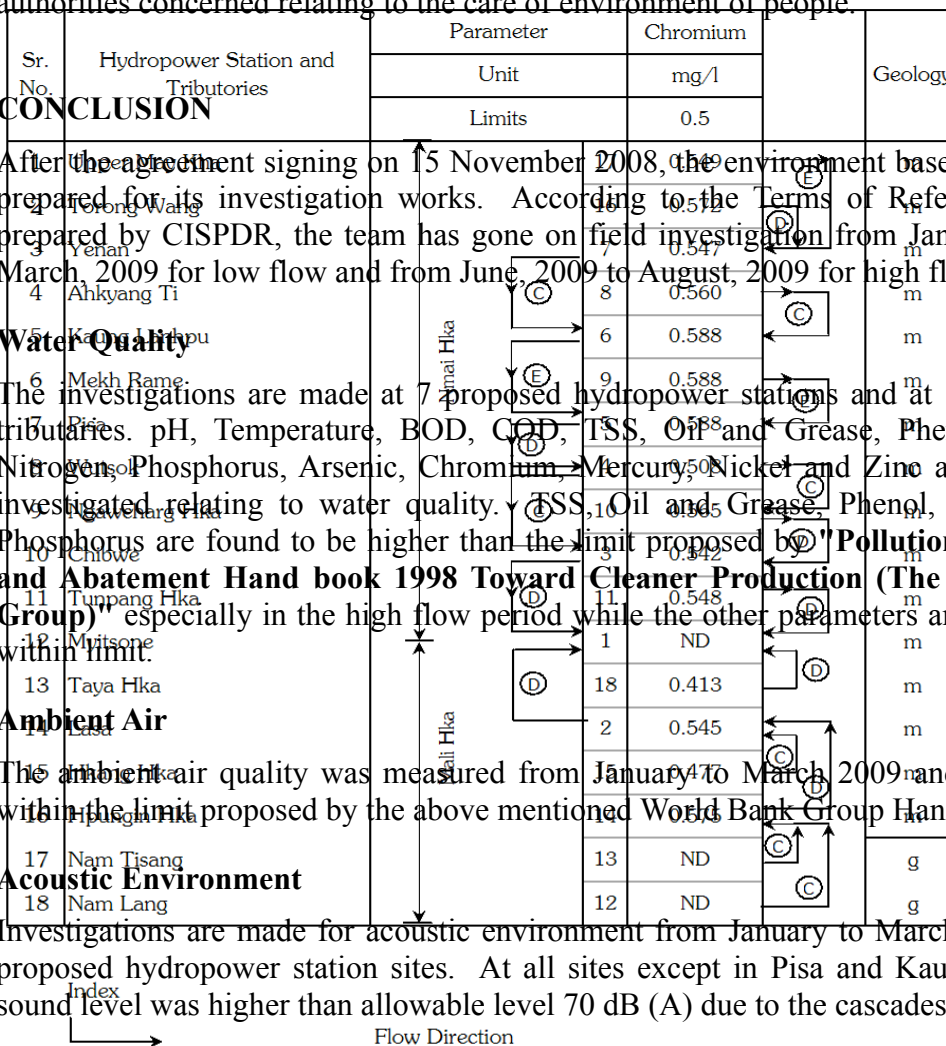
Area and Point Pollution

Pollution of water was studied at proposed hydropower station sites and around residential areas. The project area is not an industrialized and densely populated one and no trace of serious pollution was found except in Ngawchang Hka stream which is a transboundary one.

In overall aspect, it could be concluded that no significant adverse values was found relating to water, air, acoustic quality and pollution at present situation.

Chromium concentration of surface water from Yenana becomes higher at Kaung Lan Hpu, and also from Ahkyang Ti to there (see Table). That finding shows that most of the chromium deposit may be among Yenana, Ahkyang Ti and Kaung Lan Hpu. Also, surface water from Nam Tisang and Nam Lang begins to accept chromium just before Hpungin Hka. So most chromium deposit mentioned above may extend of upto Hpungin see (Fig -). Further mineral geological investigation should be done in that area.

Fig. 39 TRACE OF CHROMIUM



There were (2) major transboundary rivers bordering China in Kachin State as follows.

Basin	Trans boundary Rivers	Border Country
Nmai Hka River Basin	1. Taron wang	China

In the water quality survey of the selected observation sites, there were some significant parameters found in two rivers in Nmai Hka Basin the rivers sources of which come from China.

Oil and grease content at Wutsok is found to be 16.6 mg/l which is larger than the general water quality standard. The station observed is the upper most part of the Nawchang Hka river near the border with China.

Other parameters of significance occurrence are Phenol and Nitrogen, Phenol level along the Nawchang Hka river at high flows in the station at Wutsok, Ngawchang Hka and Chibwe (4.8, 4.8 and 5.1 respectively) are much higher than the general limit (0.5 mg/l). Nitrogen level at all three stations observed were also found to be higher at both low flow (36.4, 22.4, 19.6 respectively) and high flow (40.32-Wusok, 21.16-Chibwe) than the general limit (10 mg/l) except only at Ngawchang Hka in high flow measuring 7.75 mg/l. So Ngawchag Hka basin has less vegetative cover.

Also Phenol and Nitrogen level are relatively high at two stations observed (Toron Wang and Yenam) along the river Toron Wang the source of which is inside China. Phenol in Toron Wang and Yenam at high flow is found to be 4.7 and 4.3 which is higher than the general limit of 0.5 mg/l. Nitrogen level is much higher in both low flow and high flow at Toron Wang and Yenam stations (22.6 and 42.84 is Toron Wang, 19.6 and 15.12 is Yenam). So Toron wang basin has more vegetative cover.

Hence monitoring and control measure for Oil and Grease, Phenol and Nitrogen should be accomplished throughout and after the project life and after the project for these transboundary rivers with China.

9. DISCUSSION AND RECOMMENDATIONS

The Ayeyawady is the lifeblood river of Myanmar. It originates from the northernmost part of the country and flows towards Bay of Bengal forming the biggest fertile delta which is the rice bowl of Myanmar in south east Asia. It is navigable through out the year acting as main trunk waterways. Many towns and cities are situated along left and right banks of Ayeyarwady showing that Ayeyarwady plain is a very much dependable area for the livelihood of Myanmar people.

The project area is in that area where the Ayeyarwady originates and is the cultural heritage area of Kachin which is one of the main tribes of Myanmar. Again the area is one of the bio-diversity hot spot areas of Asia.

The Ayeyawady Hydropower Development Project could be said as a gigantic one since it is planning to produce 90.95 billion kW-h annually utilizing water from an estimated catchment area of 49000 km².

Since on one hand the water resource used in the project is the lifeblood of the country and on the other hand the development is a very big one, it is very clear and distinct that the development of the project must be considered very thoroughly from various aspects.

As described in Section 6, the fragmentation of river by dams has a very serious problem not only to the upstream of the dam but also to very far downstream till the coastal delta. The impacts of changes in flow regimes, trapping sediments and nutrients behind the dam, downstream aquatic ecosystems and bio-diversity could only be seen in long term. So the impacts are to be anticipated through past experiences and models.

Reliable and sufficient relevant data are indispensable in these anticipations. Enough time and, accordingly, budget is required for thorough investigations.

The investigation works for EIA had been done in a very limited time. A longer investigation time is strongly recommended in such a big and sensitive project which may have very significant adverse impacts. In the past, Myanmar had experienced that it takes more than five years for the feasibility evaluation to implement a project and to get World Bank loan for a medium size multipurpose irrigation and hydropower project.

The baseline study was carried out by the local scientists. Although they have good will for the study and had tried their best for the works, they may need some guidance for analysis and evaluation of some adverse impacts which are complex since the project is a gigantic and sensitive one. Well experienced international expertise is advisable for the guidance of the study.

Thorough sediment-transport studies is not implemented in the present studies. It should be included in the studies since it builds upon a good understanding of the sediment-transport dynamics and helps in estimating or quantifying the lessened amount of sediment downstream. It also serves as the basis for prevention of unwanted sedimentation.

Dam site selection studies and analyses should be done and analyzed thoroughly in all aspects, since there may be complex problems which could cause a lot of adverse effects relating to social, cultural, environmental etc. due to the construction of the dam.

Not only the benefits due to hydropower development, but also those from other developments such as eco-tourism, wild life conservation etc. should be considered in comparison although some of them may be intangible ones. Based on balancing the possible positive and adverse impacts, decision could be made whether all the potential resources or only some part should be used, in other words optimizing potential resources such as integrated water resources management for food, livelihood and nature should be studied. Sometimes, it is found that zero option is the best solution for the development.

Prioritization for implementation should be programmed in cascade dams development. The dam having relatively least adverse effects should be implemented first. Thus it will get more information and time for the development of the remaining dams and more mitigation measures are possible to be included.

Public disclosure about the development is also a useful tool. Different stakeholders, organization and concerned government agencies would get a chance to collaborate and contribute their experiences and knowledge for better developments. Giving education and information to people in the region affected by the project is also important so that they can participate in project development in the correct means.

Apart from the basic line measurements for the surface water quality, monitoring and control of pollutants in the reservoir and rivers before and after project implementation is required (see Annex).

Continued monitoring is essential through out the project life by a special team or committee organized for this particular purpose so that compensation and remedial measures can be taken as necessary. Follow up monitoring works should be planned. As the preliminary investigation team can accomplish baseline study on mainly the surface water quality at low flow and high flow only due to the available resources and time limit, a detailed and comprehensive investigation is urgently required prior to the project implementation. To measure and monitor not only the water quality at the surface but also the water quality at middle and river bed of the water body and also the

water quantity (or) runoff of the river at both low flow and high flow to determine the environmental flow after implementing the dam project is required.

General standards for discharge of effluents (CPCB 1995) and observed data at high flow

Table 31

Sr No.	Parameters	Unit	Standard			General application	Observed data range on analytical results	
			Inland surface water	Public sewers	Land for irrigation	Limit	Minimum	Maximum
1	Suspended solids	mg/l max	100	600	200	50.0	5.0 (Lasa)	550.0 (Myitsone)
2	pH		5.5-9.0	5.5-9.0	5.5-9.0	6.0-9.0	6.53 (Toron Wang)	7.52 (Tunpang Hka)
3	Temperature	°C	Shall not exceed 40 °C in any section of the stream within 15 m down stream from the effluent outlet	45 at the point of discharge			19.5 °C (Toron Wang)	33.6 °C (Tunpang Hka)
4	Oil and Grease	mg/l max	10.0	20.0	10.0	10.0	1.7 (Hpungin Hka)	192.0 (Myitsone)
5	Nitrogen	mg/l max	50.0	50.0	50.0	10.0	7.75 (Ngawchang Hka)	69.0 (Kaunglanhpu)
6	BOD	mg/l max	30.0	350	100	50.0	N.D	0.4 (Nan Tisang)
7	COD	mg/l max	250	-	-	250	N.D	52.80 (Wutsok)
8	Arsenic	mg/l max	0.2	0.2	0.2	0.1	< 0.01	< 0.01
9	Mercury	mg/l max	0.01	0.01	0.01	0.01	N.D	0.0065 (Myitsone)
10	Chromium	mg/l max	2.0	2.0	2.0	0.5	N.D	N.D
11	Zinc	mg/l max	5.0	15.0	-	2.0	< 1.0	< 1.0
12	Nickel	mg/l max	3.0	3.0	-	-	N.D	0.011 (Nanlong)
13	Cyanide	mg/l max	0.2	2.0	0.2	0.1	< 0.1	< 1.0
14	Phosphorus	mg/l max	5.0	-	-	2.0	< 0.1	7.5 (Hpungin Hka)
15	Phenolic	mg/l max	1.0	5.0	-	0.5	-	-
16	Pesticides	-	Absent	Absent	Absent	-	N.D	N.D

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APPENDIX-1

Notes on Exploration and Experiences of Field Survey Team

The experiences gained during the investigation trip (Fig. 10) are described below and the photo records are shown in Appendix-2.

Nmai Hka Basin

Transportation on mountain road

On Myitkyina-Chibwe road, 4 wheel drive cars were mostly used with axle height normally 2 feet above the road surface. Peking jeeps were found to be suitable for such roads in those areas. Survey team found logging roads in the area which facilitate access for landless settlers, miners and hunters.

The master of bows

Near Hta Phone village, the survey team found some hunters. They use bows and poisonous arrows and usually neglect the ban imposed by the authorities on hunting. Indigenous people have no knowledge on conservation of nature and they are likely to keep their habitual activities.

Dangerous foot path on mountain slope

A foot path on the steep slope of mountain on the river bank was the only way for investigation and was dangerous for the team. Sometime forest paths are about four thousand feet high from the base. Survey team was much afraid of falling down accidentally. Although they had got much help from the porters, they still experienced falling but luckily there were no fatalities. In the case of climbing steep cliff the investigation team had to hold on to branches of the nearby trees. The project area is really a wilderness.

Weather condition

Since it was raining almost in everyday, the investigation team had to work in the rain. Some team members saw much blood-sucking leeches. Sometimes clouds were seen at a level lower than the mountain. Rain lessened the tiredness of the team. The weather was cold and the team had to resist it by making a fire in their shelter. It is an indoor air pollutant.

At Kaunglanphu

It is a township level administrative place and government offices are situated in Kaunglanphu. So most of the residents are government staff. Donkeys are used for transport. Diesel generators and micro hydropower are used for electric power. The altitude of Kaunglanphu is 9680 feet. In 2008, annual rain fall was 104 inches in 174 raining days, Kaunglanphu is a potential centre for watershed management and conservation works.

Forest on the way

Few big trees were seen in the project area. Bamboos were found and too thick to pass through them. The team found so many kinds of vine and sometimes "scented wood". Banana plants grow in the area. Various orchids were in full bloom. These forests seemed to be properly managed at present time. Proper forest management involves planning for sustainable harvests while paying particular attention to forest regeneration.

Medicinal Herb

In the project area there is a kind of herb, whose leaves are boiled in water and could be used as energy drink. Local people collect and dry these leaves to sell for their use.

Scientists are now trying to make a research on these leaves. It is a non-timber forest product and could provide an income to the villagers without destroying forests.

Hot island

There is an area between Htiyi hotel and Pha Ye village which has a very hot weather like central Myanmar. It is one of the ecologically interesting places in the area.

Wildlife head

The survey team found a head of wildlife animal they had killed which was hung in one room and the skin on a tree. It was learned that one endangered tiger was once killed and sold to China. They are endangered species and irreplaceable if local people continue to kill. Population biology of these species is important.

Scarcity of food

It was noticed in the area that there were no programmes and encouragement for food production. The people in the area often had to face problems of food shortage. At that time they used to eat "Eudaing paste". They cut down "Eudaing" plant and sliced it halves and took the paste and sank it in the water. They got a paste, like "mont hnit". The crust was used as gutter, which is long and wide enough to carry water from the spring. Local people should be educated in ways of sustainable agriculture, regenerative farming or agroecology, all of which aimed at food and fibre production on a sustainable basis and prevent unwanted damage caused by destructive practices.

Natural drinking

Along the way of investigation, the team did not need to be worry about drinking water. Water naturally gushing out from the rock fissures was potable. It was natural clean water.

Mountain peak under the feet

Sunlogchat was one of the mountains with an altitude of about 8000 feet at its peak is one that the investigation team had to pass. Being a very cold and windy place, no body could stay there very long. From there is one clouds could be seen at a lower altitude.

Great effort had to be made by the team to pass through that difficult and hard place.

Unforgettable paradise

The team had stove, plates and bowls and firewood. Caretakers gave them boiled water and heated corn. A few could speak Myanmar. Most of them were Lisu and Rawan. Some could even speak Chinese. At night, the party could sleep well inside a shelter and felt like a paradise.

Fishing explosives

Fisherman of the area were not used to using boats because of the rapid. They catch fish by using explosives. The explosives were readily available at a cost of 1500 kyat. This practice should be banned to conserve fish population.

Bamboo bridge

Bamboo bridges are used to cross high valleys. Sometimes one needed to crawl along three Wabo bamboos to reach to the other side. The scene was very frightening while

crossing the very deep valleys. The investigation persons could be named as 'Adventurers'. It was also noticed that some infrastructures like bridges should be built for that area.

Deadly bridges

Suspension bridges with steel ropes are built across the rivers and stream. Timber planks of about 8 inches in width are laid in zigzag for a walk way. When one walks on it, it sways. Two ropes on the sides must be held firmly step by step. Pashim suspension bridge is the longest one that the team had passed in the area. By seeing such facilities, one could imagine the difficulty of communication in the area.

Food in the forest

The team often ate fried vegetables and salad. They grew naturally in the forest. They were "Taw-chin-paung" (wild reselle) and "Pusinam" (spear mint). Local porter made food from them. When the investigation period was longer than the estimated, the team had to face shortage of food. Then they had to solve the problem by substituting vegetables which naturally grow in the forest such as 'Taw-chin-paung', 'Pusinam'. The porters who were the local people of that area were very helpful in those situations.

The ruby mountain

It was an unforgettable scene while the sun was going down in the evening through the mountains in the west of Ngawchan Hka. The team had experienced the ruby like red sun in the clear sky. It was a beauty to see the mountain in the west near the Ngawchan Hka where the evening sun was setting in the clear sky. At that time it looked like a ruby mountain in the west. At sunset, Kachin State is a land of beauty.

Automatic pounding machine

In Kyihtan village, the villagers did not need to pound the paddy manually to get rice. They put the paddy under the fall. After two day they get rice. Two wooden arms with full energy from the water fall pound the paddy one after another. The mechanism of pounding was so eco-friendly that there was no gas emission either.

Mali Hka Basin

Famine at Zunparabun

In 1986, there once was too many rats spreading in Sanparabun. They destroyed the crops. So the people did not have enough food for a long time. There was famine and people died. That was recorded on the stone in the school compound at Zunparabun. That kind of incident was a sad ecological niche.

Needy children

It was found that the children of the area have to work for their livelihood. The children collected firewood and the food in the forest. They have not enough clothing to protect from the cold weather. When they were given instant noodles the smile on their faces could not be forgotten. "Ecofeminism reexamined relations with humans and nature. It called for a new ethic of care, reciprocity and kindness". (Ref. 8, P. 38).

Organic farming

Little terrace farming was seen in the surveyed area. Shifting cultivation was mostly practiced. The soil in the area was found to be fertile. In the area the practice of chemical fertilizer was hardly seen. It could be said that natural ecosystem still exists in the area.

The lost tributaries

Near Htan Kha village there was a tributary which flowed under the ground for about one mile. The villagers said that underground river tunnel was wide enough for a man to get along it. This tunnel is famous in the only man with obedience and respect could enter it. Cutting trees is banned. An example of the mistake of deforestation was found in Brazil where native tribal people were threatened by tropical forest destruction. Here in this place, people had lived in harmony with nature for thousands of years. Otherwise, their valuable forest ecosystem would be lost for ever.

Along the Mali Hka

There are rapids in the river Mali Hka which make navigation difficult. The boat man needed skills to pass through rapids and swift flow. By land, survey team once had a car accident on the way at the 140 mile post from Myintkyina to Putao. By a four wheel drive car, Putao could be reached from Myitkyina in 8 hours. Maliyan was a village having about 50 houses situated on the left bank of Mali Hka, 110 miles away from Myitkyina.

National park

Naungmon is a small town accessible to Putao, Kaunglanhpu and Pannandin. The famous Khakaborasi National Park which is the pride of the Kachin State is situated above Pannandin. The northern mountain range in the area looks like that of Annapurna Conservation area of snow capped Himalayan mountains in Nepal.

Control stations

There are seven control stations at the Mali Hka river. Only people and boats who have permission for pass by authorities are allowed to pass through. Due to these control station the number of people were limited which helped conservation of forest ecosystem.

Staple food

Rice is the staple food of the local people in that area. When rice was not produced enough, the natives used maize and banana as their food alternatives. The locals are practicing shifting cultivation in some areas. Agricultural education should be introduced to them for sustainable production of enough food.

Land slides

Land slides are very common and seen at the banks of rivers and tributaries after heavy rains. It is due to the lack of vegetative cover on the steep slopes. Because of land slides the river regime was degraded and turbidity increased. Care should be taken not to destroy the natural vegetative cover.

Gold mining

The gold mining industries are so prosperous that there are many food stalls, and groceries industries. There are also gambling and karaoke bars which might cause

crime and AIDS problems. Dredging, pumping in high pressure jets in gold mining might lead to a serious degradation to river ecosystem.

Tourism potential

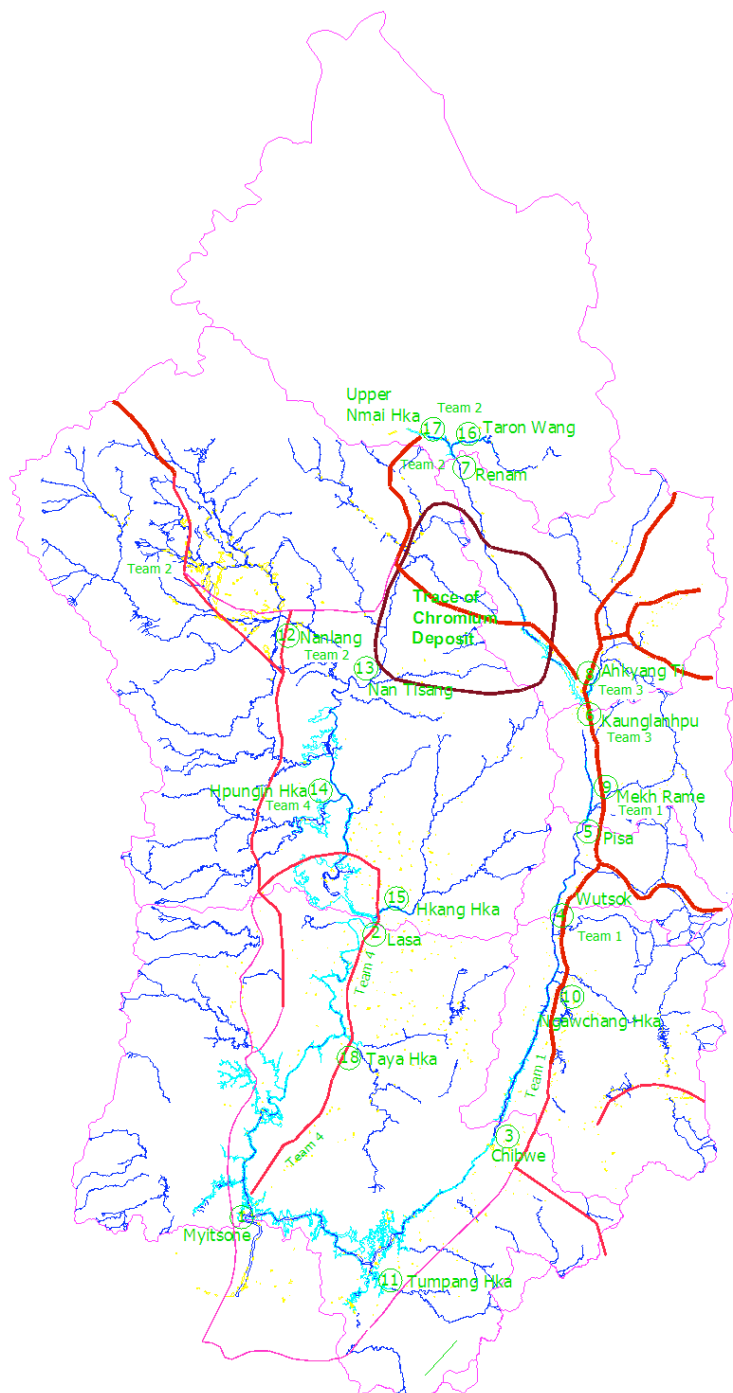
The project area is a scenic one having beautiful snow capped mountains, and forests. There are also different kinds of wildlife and it is recognized as a biodiversity hot spot area of the region. The area is the best place for sports like skiing, hiking and mountaineering. Since the area is very pleasant it has a high potential for tourism trade.

Pannandin

It is a small village having only 28 houses. Access and communication to Pannandin is very difficult. There are two helipads. Rice, potato, pumpkin and maize are grown in the area for food. Fish and meat of wildlife were also used for the meals. When the rice production was not sufficient, it was imported from Putao and China. Although it is hard to live, Pannandin is really a beautiful place from where snow capped mountains are seen in the distance.

APPENDIX – 2

FIG (40) LOCATION MAP OF THE TRIP OF SURVEY TEAM



APPENDIX - 3

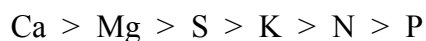
Monitoring and Control of Pollutant in Reservoirs and Rivers (Reference 18)

General

Irrespective of the nature, the mode of entry of pollutants into the water systems is often common. Broadly speaking, the pollutants can enter into water bodies by the following ways:

1. Direct discharge in the form of domestic and industrial waste waters into the system
2. Run-off and seepage
3. River flow transport
4. Reactions and transport across the water-sediment interface

Apart from the direct discharges, the major transport of pollutants from land surface to water systems takes place by run-off water which picks-up the materials (both soluble and suspended) from the soil and transport them to the receiving waters. A large quantity of soil itself can move with the run-off (soil erosion) to the bodies of water causing silting. Materials from the soils are removed mainly by leaching due to the force of percolating and run-off waters. Leaching has been reported to remove huge quantities of pollutants from the refuse tips in the cities causing both surface and ground water pollution. The rate of leaching for soil constituents has been found in the following order:



On reaching a water body, the fate and behavior of pollutants depend largely upon their nature and a variety of physical, chemical, morphological and morphometric, and biological factors. Monitoring forms an essential part of any management and pollution control programme for water bodies.

Pollution of Reservoirs

Behavior of Pollutants

The behavior and movement of pollutants in lakes, after their entry, depend upon a large number of factors. Wind action tends to circulate the water, but the depth of the mixing is determined by the temperature stratification and the depth of thermo cline. In a highly stratified body of water, the thermo cline puts a resistance to mixing, and allows only the epilimnetic upper layers to be mixed. In isothermal conditions, the mixing of pollutants may be complete, as uniform conditions prevail throughout the water column. However, the ultimate diffusion of the soluble pollutants takes place by a process called molecular diffusion.

The depth of the bodies of water is also an important factor influencing the mixing of pollutants in the whole water column. As the shallow waters are often well mixed, they provide a better mixing for pollutants in contrast to the deeper waters where only a part of the water column is mixed completely.

The transport of pollutants from the mixing point to the other portions of lake may also be influenced by the slope at the mixing point. The velocity of the drain carrying waste waters is immediately checked by the resistance put by stagnant lake water causing the sedimentation of a large quantity of suspended matter at the shore. This results in the formation of a saprobic zone in case of an entry of organic waste due to accumulation of huge quantities of organic matter in the mixing zone.

The nature of the pollutant, whether degradable, non-degradable or persistent, decides its overall accumulation in the body of water over a period of time. A reduction in

quantity occurs with time in case of degradable pollutants (both biodegradable and radioactive). Every water body has got a self-purification capacity with regard to the biodegradable pollutants depending upon the mixing characteristics and oxygen regime. The rate of inflow, outflow, seepage, overflow and evaporation are important factors deciding the net accumulation of pollutants in waters.

The pollutants can also get adsorbed onto the sediments in certain conditions, where they can live either temporarily until the conditions are reversed for their adsorptions, or can get permanently buried. Several pollutants like phosphours, ammonia and heavy metals have been found to be immobilized in this manner. A number of pollutants along with nutrients are incorporated into the body of organisms from where they are released only after their death and decomposition.

Monitoring of Reservoir Pollution

Any monitoring programme scheduled for lakes requires firstly the knowledge of morphology and morphometry which can be obtained by outline and bathymetric maps of the water body. The information regarding the catchment area is also very important and can be obtained from already existing records. The morphometric parameters of interest are usually the size, shape, area, depth, volume, length, breadth and shoreline of the water body. The point sources of pollution should be identified and marked on the maps. The samples from these entry points have to be collected regularly and an estimate of total pollution input is to be made with the help of water discharge rates and the chemical analysis data.

Due to uneven distribution of pollutants in lake waters with depth, a single sample can not be representative of the water quality for the whole lake. Several samples are usually required for a worthwhile monitoring of lakes, which should be obtained from mixing zones, downstream point, middle of the lake and some distinctly different sites owing to the peculiarity of shoreline and surroundings. The samples from these sites should be collected at least from three depths, i.e., surface, middle and bottom. The bottom samples give an idea of the accumulation of pollutants near the sediment-interface.

The depth samples can be collected with the help of some suitable depth samplers like Von Dorn bottle or other devices. The collected samples are transferred to the laboratory immediately after collection for the detailed chemical and biological analysis. Some chemical parameters like dissolved oxygen, free carbondioxide and pH are normally analyzed at the field as they rapidly change with time. The common parameters analyzed in any monitoring programme may include the following:

Physical: Temperature, colour, solids, turbidity, conductivity.

Chemical: Dissolved oxygen, BOD, COD, pH, alkalinity, redox potential, ammonia, nitrate, nitrite, sulphate, phosphate, chloride, calcium, magnesium, hardness, sodium, potassium, iron, heavy metals pesticides, detergents and any other pollutant of interest.

Biological: Coli forms, pathogens, plankton (both phytoplankton and zooplankton) macro-invertebrates.

Control of Reservoir Pollution

The first step in any management and control programme of lake pollution is to carry out a regular monitoring with regard to the parameters described above. The data obtained through this monitoring shall help in assessing the current trophic status and level of pollution. Net accumulation of pollutants can be worked out from the input and

output data for various pollutants. Long term trends can also be evaluated from a regular and continuous monitoring data.

Some important control measures usually employed for lake pollution are diversion of nutrients, removal of pollutants and nutrients from waste waters, removal of nutrients from lakes, and proper land management in catchment area.

Pollution of Rivers

Behavior and Fate of Pollutants

The most basic characteristic of the river system is the presence of a current which plays a dominant role in habitat conditions, distribution of the constituent, and horizontal movement of water mass. The changing boundary conditions and the catchment area throughout the length of a river system can totally change the characteristics from one section to another. This indicates that no two rivers or the portions of a river are identical, which makes it apparent that each river or each portion is unique in many respects and should be investigated accordingly. A river system provides a very short residence time to water in contrast to the lake which provides usually a long retention time.

The rivers receive pollutants from both point and non-point sources. The point sources are commonly the discharges of sewage and industrial wastes of varying characteristics and load. The flowing nature of rivers imparts them a comparatively higher self-purification capacity. The organic matter is decomposed at a faster rate with flow because of the greater re-aeration of oxygen from the atmosphere by turbulence. Thus, the oxygen which falls suddenly after an organic outfall can be replenished quickly after some distance in a river.

The conservative pollutants (non-degradable) tend to concentrate in the river systems. However, after their entry they get diluted in water with flow, while some are absorbed to the bottom sediments and some get incorporated into the body of organisms. This indicates that, while the concentration of these pollutants in water may dilute, they remain essentially unchanged in quantity in the river system. The conservative pollutants in river progressively increase in concentration with time in case of their continuous discharge by outfalls.

The bacteria and other microorganisms including pathogens, introduced by outfalls, meet the fate of natural death reducing their density with flow. However, if the sources of pollution are spaced near to each other, as often the case when a river passes through a city or an industrial area, a required stretch may not be available to the river for self-purification. This makes the pollutants to accumulate in these areas to dangerous levels. An excessive accumulation of organic matter will result in oxygen depletion, or its complete elimination from the water.

Monitoring of River Waters

The overall monitoring of any river basin shall depend on the basic objective for which it is to be carried out. The major objectives of the river monitoring may include one or more of the following:

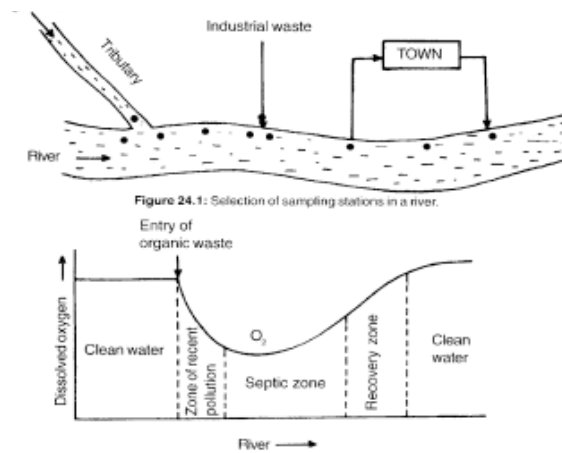
1. To assess immediate water quality in the river.
2. To enforce water quality standards, detect offenders and ascertain improvements owing to the abatement measures.
3. To predict future changes in water quality resulting from the developmental activities in the region.

4. To provide an early warning system for downstream users about adverse water quality conditions.
5. To determine timing for flow increase or stream treatment.

The sampling stations in a river are usually decided after a preliminary survey of the stretch of the basin taking following aspects into consideration.

1. Points of entry of waste waters along the river.
2. Points of entry of freshwater tributaries.
3. Points where there is significant changes in the width, velocity, slope or depth of the river.

The selection of sampling points for a routine water quality monitoring has been illustrated in Fig. In a heavily polluted river by organic discharges some additional samples can also be drawn below the outfall representing the zone of recent pollution, saprobic zone, recovery zone and clean water.



Various zones in a river after the addition of an organic waste

The collected samples are analyzed for the parameters already indicated earlier for lake monitoring. Besides the usual physico-chemical and biological parameters, additional information is also required on hydrology of the basin, flow rates of both discharges and river, average depth and width of water at the sampling stations, distance between the two sampling stations, and meteorological information, to correctly interpret the results.

Control of River Pollution

Following approaches can be considered for control river pollution:

1. The most usual approach for river pollution control is to lay down standards governing the stream water quality and effluents discharged into it. Streams are generally classified according to the major use to which they are likely to be put, i.e., drinking, fish culture, irrigation, bathing etc. Each use requires some minimum water quality for which the standards can be applied.
2. At the time of lean flow seasons, the pollutants are likely to be concentrated in greater quantities, which can be controlled by augmenting the flow of water in the river by extra discharge from the upper reservoir.
3. At certain times in dry season, when the self-purification capacity is reduced considerably, extra oxygen can be provided by artificial aeration at the desired points. However, this method is costly and less feasible, but can be applied in emergency situations.
4. All the waste waters entering into a river system should be allowed only after a proper treatment. This can reduce the pollution load to a desired level calculated on the basis of stream