LITERATURE REVIEW

Watershed Management

Definition and Objectives

A watershed is a topographically delineated area that is drained by a stream or river system (Easter and Hufschmidt, 1985). The watershed is a hydrologic unit that has been described and used both as a bio-physical and socio-economic unit for planning and implementing resource management activities including water quality management. Watershed and their proper management have become a major focus for resource managers around the world, including Thailand. Many scholars have given various definitions of watershed management to reflect what should be encompassed by management of the watershed in order to reach the desired goals. Traditionally, management was viewed as a biophysical problem complicated by the presence of people. More recently, watershed management has considered to be an integrated process whereby a natural resource is managed in conjunction with human use to produce a series of goods and services. (Chunkao, 1972; Dixon and Hufschmidt, 1986; and USDA, 1990)

Watershed management is the management of existing resources in a watershed in order to obtain sufficient quantities and quality of water at required times, as well as to control the stability of soil and other resources in the watershed for the benefit of people living within it. In addition, watershed management is typically viewed as a combination of management activities done in order to obtain sustainable production (Chunkao, 1996). From a larger perspective, watershed management is the integrated process of formulating and implementing a course of action involving natural and human resources, taking into account the social, political, economic, and institutional factors operating within the watershed and the surrounding river basin to achieve specific environmental and social objectives (Dixon and Hufschmidt, 1986).

Watershed management has manifold objectives:

1) to control the volume of water to avoid excess in the rainy season and shortage in the dry season,

2) to obtain water of good quality free of toxic elements in terms of chemicals and living organisms visible and invisible to the naked eye,

3) to ensure a continuous supply of water throughout the year,

4) to control or prevent soil erosion when human activities are being carried out in the watershed,

5) to ensure proper safety measures to mitigate damage from flooding , and

6) to implement suitable watershed conservation practices.

Thus to accomplish the desired objectives stated above, watershed management emphasizes (1) land use planning (2) resource utilization and conservation, and (3) pollution control (Chunkao, 1996).

The Watershed System

Beside the view of watershed as a hydrological unit, many recognize watershed as a system pertaining an environmental or ecological characteristics. As its interrelationship between bio-physical components within the watershed creates energy flows and material cycles. Watershed also has upstream and downstream relationships that impact from upstream ecosystem can affect the downstream ecosystem. Finally, watershed system can be managed by manipulation interaction of inputs, output, and regulators of the watershed.

In terms of watershed management, watershed boundaries are appropriate ecological boundaries for resource management. The watershed approach or ecosystem approach encourages analyst and planners to consider the “big picture” by emphasizing the entire system, their component parts, and the interrelationships between those parts (Mitchell, 1997). Such a perspective is important, as it brings to mind to us that many water problems (e.g. pollution and flooding) cannot be resolved by focusing only on water. Many sources of pollution are from land-based activities, and flood damage potential is strongly influenced by land uses. Conversely, many land-based problems (e.g. declining agricultural productivity and loss of biodiversity) occur from too much or too little water. Thus, it is important that we consider the “big picture”, and not become unduly focused on one element or component of an ecological system. However, a danger arises when the“big picture” becomes too big, planners and analysts may become so entangled in the complexities of multiple components and linkages that they would be unable to complete their analysis within a reasonable period.

Watershed Management Approach

The watershed management approaches aim to prevent pollution, achieve and sustain environmental improvements and meet other goals important to the community. Although watershed management approaches may vary in terms of specific objectives, priorities, elements, timing, and resources, all should be based on the following guiding principles (EPA, 1992a):

a) Partnerships: Those people most affected by management decisions are involved throughout and shape key decisions. This ensures that environmental objectives are well integrated with those for economic stability and other social and cultural goals. It also provides that people who depend upon the natural resources within the watershed is informed of and participate in planning and implementation activities.

b) Geographic focus: Activities are directed within specific geographical areas; typically the areas that drain to surface water bodies or those that overlay and recharge ground waters or a combination of both.

c) Management techniques based on basic science and data collection: Watershed stakeholders employ scientific data, tools, and techniques in an interactive decision making process. This includes: (1) assessment and characterization of natural resources and the communities that depend upon them; (2) goal setting and identification of environmental objectives based on the condition or vulnerability of resources and the needs of the aquatic ecosystem in the community; (3) identification of priority problems; (4) development of specific management options and plans; (5) implementation; and (6) evaluation of effectiveness and revision of plans, as needed.

Because stakeholders work together, actions are based upon shared information and a common understanding of the roles, and responsibilities of all involved parties. Concerns about environmental justices are addressed and, when possible, pollution prevention techniques are adopted. The iterative nature of the watershed approach encourages partners to set goals and targets and to make maximum use of available information while continuing analysis and verification in areas where information is incomplete.

In addition, the most significant outcome of the United Nations Conference on Environment and Development "The Earth Summit" held in Rio de Janeiro in June 1992 was Agenda 21. This document was set to guide and drive action towards sustainable development as a key text for all concerned with policy and practice. The Local Government Management Board in the Unite kingdom has produced a simplified guide to Agenda 21 (DeBarry, 2004).

"Water resources must be planned and managed in an integrated and holistic way to prevent shortage of water, or pollution of water sources, from impeding development. Satisfaction for basic human needs and preservation of ecosystems must be the priorities; after these, water users should be changed appropriately. In 2000 all states should have national action programs for water management, based on catchments or sub-basins, and efficient water use programs. These could include integration of water resources with land use planning and other development and conservation activities, demand management through pricing or regulation and conservation, reuse and recycling of water".

In order to be implemented in reality, sustainable development, which is based on such action plans, must satisfy criteria in at least three major dimensions: Ecological, Social and Economic (ESE). The general aspirations or criteria of social and economic dimensions are relatively easy to identify. However, the processes of ecological phenomena must be further studied to gain a better understanding to aid the setting up of appropriate criteria.

At present, the institutional factor plays an important role in watershed management. There are many agencies related to the supervision of the structure and composition of existing resources in the watershed. These agencies support any efforts to achieve watershed management objectives. These include a national agency, ministerial and departmental agencies, as well as provincial and local agencies (Chunkao, 1996).

In the past, more top-down management and planning activities took place in watershed management. Institutions at national and regional levels played major roles in watershed management. However, in more recent times, the situation has been changed. More emphasis is given to local authorities such as Sub-district administrative organization (SAO) in terms of natural resource management according to the current Thai Constitution. Roles and responsibilities of central government have changed to focus more on national policy control and support to local authorities in local watershed management. With this regard, local authorities must step up to build their own management capacities in order to manage their watershed properly.

Roles and Responsibilities of SAO in Resources Management

Sub-district administrative organization (SAO) is a local administrative agency established by the Act of the sub-district Council and SAO, 1994. Thailand had as many as 6,746 SAOs in 2000 (Department of local administration, 2000). Of this number 1,493 (22.13 %) were located in the north, 481 (7.13 %) in the east, 1,020 in the south (15.12 %), 1,138 in the central region (16.87 %) and 2,617 (or 38.75 %) in the northeast.

The structure of administration in the SAOs is composed of two parts as follows (Department of Local Administration, 1996):

The SAO council comprises of two types of members. One type of membership is in line with the initial structure as required by the Act of sub-district Council and SAOs (1994). This kind of membership includes legal positions such as the village chief, sub-village chief, and sub-district doctor and two members from each village appointed by electoral vote. The other type of membership is in line with the new structure required by the Act of the sub-district Council and SAOs (1999). This kind of membership includes two members from each village appointed by electoral vote. In the case, any SAO has only one village, the council should comprise of 6 members. If it has two villages, the membership should be made up of three representatives from each village.

The administrative committee for the SAOs is composed of two membership types. One is the SAO which was set up in 1997. It has seven members on its administrative committee that includes the village chief (legally appointed), sub-village chiefs by selection (not more than 2 persons) and council members of SAOs (not more than 4 persons). The other is the SAO, which was established in 1995 and 1996. It has three members on its administrative committee, which includes a chairperson of the committee appointed by selection from the public, and two others appointed by election from the council of SAOs. The assistant officer of the SAOs is the secretary of the committee.

The internal administrative structure consists of sub-district officers who are permanent government officers working in the field of public health. The assistant officer of the SAO functions as a leader under the supervision committee.

The implementation of the SAOs is under the legislation stipulated in Items 66, 67 and 68 according to the Act of the sub-district Council and SAOs (1994). As stipulated in section 2 item 16 of the Act of Specification and Producer for Decentralization to the Local Administration Organization (1999), the SAOs have the authority and mandate of organizing a public administration system for the benefit of the people in their own areas. The roles and responsibilities of the SAOs are in four sectors: economic aspects, society and services, education and culture, and natural resources and environmental management. The details of each sector are as follows:

Economic aspects

The SAO is responsible for seeking suitable economic benefits through management. Moreover, it functions by the promotion and teaching of work opportunities for local people, the encouragement of farmer groups and cooperatives, the support of the domestic industry, the supervision of husbandry, the control of slaughterhouses, the promotion of commerce and investment, and the facilitation of the market, pier (where present) and parking as well as the promotion of tourism.

Society and services

This sector focuses on public utilities, public affairs and construction. Furthermore, it includes transportation and traffic engineering, facilitation of electricity and power, public health, nursing, prevention of communicable diseases, leisure and public parks, sports and sport stadiums, peace affairs, safety in lives and property, cleanliness and order of the city, entertainment and public places, public hazards, cemetery maintenance, social welfare, development of women, children, youth, the elderly, and the handicapped, and promotion of democracy, equality and human rights.

Education and culture

It is involved with the promotion of education, religion and culture, art and tradition, local wisdom, and local culture as well as the encouragement of public participation in local development.

Natural resources and environmental management

Natural resources and environmental management is concerned with the maintenance of water, land, and water drainage, water for consumption and agriculture, the cleanliness of roads, waterways, footpaths and public places, the limitation of garbage, wastes and water pollution, the improvement of slums, living places, and public affairs, the management and utilization of forests, land, natural resources and the environment, the preservation of natural resources and environment, the supervision of public property, city planning, and building control.

In addition, the SAOs should design a local development plan on its own and carry out any activities that are of benefit to the local people, as indicated by the committee.

Role of SAOs Associated with the 1997 Thai Constitution

According to the Thai Constitution of 1997, the duties and responsibilities of the government regarding natural resources and the environment for the local people and communities are identified item 79 in section 5. These items are the main framework for natural resource and environmental management and state that "the government must promote and support public participation in preserving, conserving, and promoting environmental quality in accordance with the principle of sustainable development as well as controlling and limiting pollution which may result in the lesson of hygiene, safety and quality of life”.

The terms of the “local administrative agencies” roles in environmental management related to culture and surroundings, have been clearly stated in items 289 and 290. The statement says that the local administrative agencies maintain the local arts, tradition, local wisdom, or good culture, and promote and preserve environmental quality in the form of managing, and utilizing natural resources and the environment existing in the local areas. Furthermore, it includes the principle of participation in maintaining natural resources and the environment outside the particular local areas, which may affect the quality of life of people in their own areas, and participation in the initiation of projects or activities outside the particular areas, which may affect the environmental quality or hygiene of the local people (Department of Local Administration, 2000).

Roles of the SAOs associated with the Enhancement and Conservation of National Environment Quality Act of 1992

The authorities of the SAOs are also involved with Enhancement and Conservation of the National Environment Quality Act of 1992, particularly in matters of natural resource and environmental management, resource uses and maintenance, environmental quality management plans as well as waterways maintenance, facilitating water for consumption and agriculture, preventing, monitoring and mitigating water pollution, and designing local development plans and environmental quality management plans in local areas. To achieve this intention, it is necessary for the SAOs to obtain knowledge and understanding of the factors involved, especially base line data. This is essential for decision-making and planning along with identifying objectives or programs (Department of Environmental Quality Promotion, 1994).

Yingworaphun (1999) reported some problems, obstacles and constraints in resource management by SAO.

Problems in Sub-District Development Planning

Most administrators in the SAOs lacked vision in planning comprehensively for the next three to five years. Issues involved in sub-district development planning include budget constraints, inefficient and/or obsolete data, and inadequate experience and knowledge in planning of the staff concerned.

Problems and Unpreparedness of the People

Since the SAO is a new agency, local people are not familiar with the SAO's new roles. Moreover, there is no proper link between the people and SAOs. Public relation activities regarding the performance and activities of the SAOs are undertaken to a small extent only. This results in local people lacking knowledge and understanding as well as full support of SAO work. Thus, they have not joined in any concerted efforts and activities.

Problems with the Authority of the SAO

According to the laws concerned, the SAO has been designated as having a major role in sub-district development, in terms of economic, social and cultural aspects, and other missions as required. However, most SAOs do not play their roles as designated. They only pay attention to facilitation of the basic infrastructure development. There is insufficient of public participation in the assessment of their performance.

Water quality

Definition

Water is a compound substance. The molecule of water is composed of two covalent bonds linking two atoms of hydrogen and one atom of oxygen. The chemical formula of water is H_2O. Water is an essential substance in sustaining human and other life forms. It can be said that the social and economic growth and particular evolution of Thai tradition have always been linked to water concerns. About 97 % of water volume in the world is found in the oceans. Only 0.63 % of surface and underground water sources are utilized. The remaining water is ice at the pole. Naturally, available water comes from precipitation such as rain and snow. When it cycles through the earth's atmosphere, it dissolves gases and other substances. Thus, precipitation always contains oxygen and carbon dioxide. When water reaches the earth's surface it is called surface water and will drain through streams and rivers or permeate to underground and become ground water. This is called "hydrological cycle" (Hygiene Division, 1999).

The quality of surface and ground water depends largely on the substances that are contaminated within the hydrological cycle. Water quality is closely linked to the surrounding environment and land use. Water quality in our environment is usually affected by community uses such as agriculture, urban and industrial use, and recreation. The modification of natural stream flows by dams and weirs can also affect water quality (Denison, 1993).

The Environmental Protection Authority (NSW) (2006) explains in www.epa.nsw.gov.au/envirom/water quality that generally the water quality of rivers is best in the headwaters, where rainfall is often abundant. Water quality often declines as rivers flows through regions where land use and water use are intense and pollution from intensive agriculture, human settlements, industrial and recreation areas increases. Rivers frequently act as conduits for pollutant by collecting and carrying wastewater from catchments and, ultimately, discharging it into the ocean.

The presence of contaminants and the characteristics of water indicate the quality of water. These water quality indicators can be categorized as:

- **Biological:** bacteria, algae
- **Physical:** temperature, turbidity and clarity, color, salinity, suspended solids, dissolved solids
- **Chemical:** pH, dissolved oxygen, biological oxygen demand, nutrients (including nitrogen and phosphorous), organic and inorganic compounds (include toxicant)
- **Aesthetic:** odors, taints, color, floating matter
- **Radioactive:** alpha, beta and gamma radiation emitters.

Water Quality Indicators

The quality of water depends on substances mixed in the water such as gas, sodium chloride, heavy metal, other chemical substances and bacteria. Water quality standards have been used to select the water source for consumption for a long time (Hygiene Division, 1994). In general, standards for clean water for consumption should be clear with no color, odor or taste. The use of human senses is a simple method for assessing water quality. Technological development has resulted in more pollutants contaminating the environment. In this regard, the use of only human senses for assessing water quality from its physical characteristics may not be sufficient to ensure quality. This is because some substances can dissolve very well in water. Such substances include lead, cyanide, and bacteria and most of the time they cannot be detected by normal human senses. However, other methods of water quality measurement have been developed varying from very simple to complicated methods.

Water quality indicators are determined by the water's physical, chemical and biological properties, which can have a profound impact on the overall health, or ecological state, of the water (Colley, 1993). The following terms are frequently used to describe the results of analysis of the water quality status of streams.

Physical indicators

Temperature

Temperature is important to many chemical factors (Horne and Goldman, 1996). For instance, temperature can influence the rates of chemical reactions, the rates of plant growth such as algae, the amount of oxygen dissolved in the water, and whether or not compounds remain bound to the sediments or become dissolved or suspended in the water column. Temperature is a critical water quality parameter, since it directly influences the amount of dissolved oxygen that is available to aquatic organisms. Thus, temperature is a key determinant of what species can survive in a particular environment. Temperature preferences vary widely among species and all species are negatively impacted by rapid fluctuations in temperature. Desired temperatures depend on the desired use of the water body. Temperature is a measure of how cool or how warm the water is, expressed in degrees Celsius (C).Water quality standards dictate that water should have a temperature no less than or greater than 10 degrees Celsius from air temperature.

Odor

Water with bad odor can cause humans to refrain from use of the water (Canter, 1985). It is also an indicator of other water quality properties such as a lack of oxygen in the water.

Turbidity

Turbidity is a measure of the clarity of the water (Barth, 1990). It is the amount of solids suspended in the water. It can be in the form of minerals or organic matter. It is a measure of the light scattering properties of water, thus an increase in the amount of suspended solid particles in the water may be visually described as cloudiness or muddiness. Turbidity is measured in Nephelometric Turbidity Units (NTU). Turbidity samples should be tested in the office at the end of the day and results recorded on data sheets. If they are left overnight, they should be stored in a refrigerator at the office. If the turbidity samples are taken to a laboratory, they must be tested within 30 hours from the time they were collected in the field (Coots, 1994).

Color

Color is typically a result of the presence of metallic ions or organic matter, such as peat, humus, or weeds, in the water. Color can also indicate the presence of certain types of runoff or discharges into the water; it comes from some substances dissolved in the water. For example, water that has high amounts of iron is often bright yellow. This kind of color reflects the compounding of soil, the decaying of plants, the emerging of algae, a high volume of fertilizer or organic substance, or the decomposition of waste products (Colley, 1993).

Conductivity

Conductivity is the ability of the water to conduct an electrical current, and is an indirect measure of the ion concentration (Dennison, 1989). The more ions present, the more electricity that can be conducted by the water. This measurement is expressed in microsiemens per centimeter (µS/cm) at 25 degrees Celsius.

Alkalinity

Alkalinity is a measure of a stream’s pH. It is often referred to as the buffering capacity of a stream because it allows a stream to neutralize acidic pollution or contamination. It is the best measure of a stream’s sensitivity to acid inputs. Abrupt changes in alkalinity may signify pollution. Without neutralizing capacity, any acid added to a stream would cause an immediate adverse change in pH. Levels between

100 and 200 mg/L provide ideal buffering within a stream; endurable pH levels may be maintained at this level of alkalinity. This also protects aquatic life from acidic shock, which occurs when there is a sudden decrease in pH that aquatic life cannot rapidly adapt to in order to survive. Alkalinity is greatly determined by the type of underlying bedrock and soil through which the water flows. High values may be caused by sewage and livestock waste. Values in excess of what bedrock types indicate as normal may be the result of sewage, livestock wastes, the production of concrete or a combination of these. Very low readings may be due to heavy rains or other acidic contamination. Abrupt changes may signify pollution (Dennison, 1989).

Total Hardness

Calcium, magnesium, and carbonate are the major components of hardness, which is the amount of dissolved minerals in water. Minerals are dissolved from bedrock and soil as water passes through them (Maidment, 1993). The calcium component of hardness is very important to aquatic life, as it is used for the cell walls of plants and the shells and bones of aquatic organisms. Hard water aids buffering capacity, as heavy metals and other toxic compounds may be more detrimental in soft water than in hard water. Tests usually measure the calcium and magnesium carbonate concentration in a water sample. High levels of hardness can cause precipitation and deposition of calcium carbonate on the stream bottom, which disrupts normal stream activity. Water with high hardness may also cause plumbing problems. Optimal values of hardness of aquatic life range from 100 to 200 mg/L. At levels above 250 mg/L, calcium carbonate will begin to precipitate. Hardness values should be slightly higher than alkalinity values. If there is a major difference between the two values, chloride and sulfate ions may be present. High hardness values are often associated with limestone formations.

Total Solids

Total solids include suspended solids, dissolved solids. Dissolved solids are small enough to pass through a filter with holes about 2 microns in diameter. They are measured in mg/L and include silt, clay particles, plankton, algae, fine organic debris, and other particles. It is tested because aquatic organisms may shrink or swell depending on the level of solids. Organisms in water with a low level of solids may swell due to water moving into their cells. This effect may cause organisms to float or sink in water columns to a level at which they are not adaptable. Solids come from industrial discharges, sewage, fertilizer, road runoff, and soil erosion (EPA, 1992b).

Suspended Solids

Suspended solids are all particles in water that will not pass through a filter having openings of 0.45 microns in diameter. Typically, suspended solids include items such as soil, algal cells, and plant particles. High levels may smother aquatic organisms. It is recommended that suspended solids not exceed 25 mg/L. Unpolluted streams usually have concentrations less than 10 mg/L. High suspended solids may occur below sewage treatment plants, construction sites and farms where erosion rates are high, various industries, and below algal-choked lakes (U.S.D.A, 1990).

Chemical indicators

Water quality criteria for individual chemicals are derived from laboratory studies of biological organisms' sensitivity to specific chemicals or combinations of chemicals. Based on tests, guidelines or national criteria are established by The Pollution Control Department (PCD). Thailand uses these recommendations in combination with the latest scientific information in setting the appropriate chemical water quality criteria for surface water. A subset of chemical criteria is associated with the Agricultural Water Supply use designation. Use of these criteria help protect against long term adverse effects on crops and livestock as a result of crop irrigation and livestock watering. Chemical indicators are as follows:

pH

pH, or the "potential of hydrogen", is a measure of the concentration of hydrogen ions in the water (Barth, 1990). This measurement indicates the acidity or alkalinity of the water. On the pH scale of 0-14, a reading of 7 is considered to be "neutral". Readings below 7 indicate acidic conditions, while readings above 7 indicate that the water is alkaline, or basic. Naturally, occurring fresh waters have a pH range between 6 and 8. The pH of the water is important because it affects the solubility and availability of nutrients, and aquatic organisms can utilize them. Variations in pH affect chemical and biological processes in water. Low pH increases availability of metals and other toxics for intake by aquatic life. It is critical to survival, growth, and reproduction of fish and macro invertebrates to maintain a constant pH. Exposure to very low or high pH may cause death or reproductive problems for fish and other aquatic life. Slight variations of pH on a daily basis or major changes over time can cause extreme stress to that species. A range from 6.5 to 8.2 is optimal for most organisms. The PCD standard is between 6 and 9. Dissolved minerals from rocks and soil contribute to pH, but reaction of dissolved carbon dioxide with water is a major determinant. Sources of abnormal acidic readings include acid mine drainage, industrial effluent, acid rain, sewage lagoons, and livestock containment areas. Sources of alkaline conditions include concrete plants, water treatment plants, and raw sewage.

Dissolved Oxygen

Dissolved oxygen is the amount of oxygen dissolved in water, measured in mg/L (Coots, 1995). It is absorbed from the atmosphere and from photosynthesis. Its concentration is related to the temperature and density of the water. A stream with running water will contain more dissolved oxygen than still water. Cold water holds more oxygen than warm water. If more oxygen is consumed than produced, some organisms die due to low oxygen levels. Some organisms require more oxygen than others require and are more sensitive to sudden changes in dissolved oxygen than others. PCD standards are based upon the classification of the water body. Dissolved oxygen levels of at least 4-5 mg/L are needed to support a wide variety of aquatic life. Trout require at least 7 mg/L dissolved oxygen for unimpaired reproduction. Spikes in dissolved oxygen may indicate sources of pollution. Because of its churning, running water will contain more dissolved oxygen than still water. Very few species can exist at levels below 3 mg/L. Wastewater from sewage treatment plants, storm water runoff, and failing septic systems. Low values can sometimes be attributed to poorly shaded water, which can cause warming. Plant life also influences the content. In areas of dense algae growth, dissolved oxygen levels are likely to drop significantly at night and increase excessively during the day. Respiration by aquatic animals and various chemical reactions consume dissolved oxygen in water.

Biological Oxygen Demand (BOD)

Biological Oxygen Demand (BOD) is a measure of how much oxygen is used by microorganisms in the aerobic oxidation, or breakdown of organic matter water (Cusimano, 1994). Usually, the higher the amount of organic material found in the stream, the more oxygen is used for aerobic oxidation. This depletes the amount of dissolved oxygen available to other aquatic life. This measurement is obtained over a period of five days, and is expressed in mg/L.

Chemical Oxygen Demand (COD)

Chemical Oxygen Demand (COD) is an alternative method of measuring the oxygen used for the degradation of organic materials and some inorganic materials (Barth, 1990). COD is the volume of oxygen which has reacted with organic carbon in intense acid conditions. The decomposition of organic carbon through aerobic microbes is called BOD. It is measured after 5 days at a temperature of 20 degrees Celsius. It can be said that BOD-5 is only part of BOD-20. According to the study, BOD-5 is about 70 to 80 % of BOD-20. The sources that have contributed to the occurrence of organic carbon are houses and industrial plants that release wastewater to water sources. Thus, oxygen in the water sources is reduced. To sum up, BOD and COD are measurements used to identify the requirements for oxygen in the water. In general, COD is more than BOD.

Nitrogen

Nitrogen exists in several forms in the aquatic environment. At high concentrations, water is unsafe to drink due to the possible presence of altered forms of nitrite, which may cause serious illness to both humans and wildlife. Unpolluted water will normally have a nitrate level less than 1 mg/L. The PCD water quality standard for nitrate is 10 mg/L. Sources of abnormally high readings could come from fertilizer runoff resulting from improper application, human and animal wastes from failing septic systems and livestock confinement areas, and decomposing organic matter (Cusimano, 1991).

Nitrite

Nitrite is one of the forms of nitrogen found in aquatic ecosystems. Others include ammonia and nitrite. Nitrate is the most completely oxidized state of nitrogen commonly found in water, and is the most readily available state utilized for plant growth. Since nitrate plays a key role in stimulating plant growth, it is heavily used as a nutrient component of fertilizer. High nitrate levels combined with phosphates cause excessive plant and algae growth, a deteriorating process called eutrophication. It causes changes in the types of plants and animals living in a stream, may lead to low dissolved oxygen levels, and may cause temperature increases. Higher concentrations in water are unsafe to drink due to the possible presence of altered forms. Unpolluted waters normally have less than 1 mg/ (Cusimano, 1991). The PCD water quality standard is 10 mg/L. Sources of nitrate include fertilizer runoff resulting from improper application, failing septic systems, animal wastes from livestock confinement or manure storage areas, decomposing organic matter, and industrial discharges containing corrosion inhibitors.

Ammonia

Ammonia (NH_3) is produced by the decomposition of organic nitrogen-containing compounds (Dickes, 1992).

Phosphates and Ortho-phosphate

Organic phosphates are associated with living material and can be used by animals. It is an essential nutrient for plant and animal growth. Slight increases may cause numerous undesirable effects, such as accelerated plant growth, algae blooms, low dissolved oxygen levels, and death of certain aquatic organisms. Water with phosphate levels below 0.03 mg/L is generally considered unpolluted. Levels between 0.03 and 0.1 mg/L are sufficient to stimulate plant growth. The critical level for avoiding severe impact is 0.1 mg/L. Sources of phosphate include wastewater from sewage treatment plants, fertilizer runoff, faulty septic systems, livestock confinement areas and manure storage facilities. Ortho-phosphate is one form of phosphorus found in natural waters. Other forms of phosphorus found in natural waters that are not tested include polyphosphates, and organically bound phosphates. Ortho-phosphate is the tested form of phosphate because it is the form of phosphate used in fertilizer and applied to agricultural fields and residential lawns. Like nitrates, phosphates negatively influence water by causing accelerated rates of eutrophication. Phosphate levels below 0.03 mg/L are generally considered unpolluted. Levels between 0.003 and 0.1 mg/L are sufficient to stimulate plant growth. The critical level for avoiding accelerated eutrophication is 0.1 mg/L. Levels above 0.1 mg/L are considered problem areas. There has not been a standard set for safe drinking water because humans can tolerate extremely high levels before it even takes effect on the digestive system. Phosphates naturally found in water are derived from decomposing organic material and leaching of phosphorus-rich bedrock. Sources of abnormally elevated readings would come from fertilizer runoff, human and animal waste from failing septic systems, sewage treatment plants, and livestock confinement areas, mass quantities of decomposing organic matter, industrial effluent, and detergent wastewater. Detergent wastewaters are responsible for about half of the polluting phosphates (Horne and Goldman, 1994).

Phosphorus

Phosphorus is an essential nutrient for plant and animal growth, and is normally in short supply in natural systems (Dennison, 1989). There are many forms of phosphorus but pure elemental phosphorus is rare. Organic phosphates are associated with living material and can be used by animals, whereas inorganic phosphates are forms required by vegetation. Phosphorus may be dissolved or suspended in a water body. Slight increases may cause numerous undesirable effects, such as accelerated plant growth, algae blooms, low dissolved oxygen, and the death of certain aquatic organisms. Phosphate levels below 0.03 mg/L are generally considered to be unpolluted. Levels between 0.03 and 0.1 mg/L are sufficient to stimulate plant growth. The critical level for avoiding severe impact is 0.1 mg/L. It naturally exists in rocks, soil, and animal wastes. It can also come from wastewater from treatment plants, fertilizer runoff, faulty septic systems, livestock confinement areas or manure storage facilities, and detergent wastewater.

Potassium

Potassium is an essential element in both plants and animals. Potassium is present in plant material and is lost by crop harvesting and removal, as well as by leaching and runoff from organic residues (Dennison, 1989). Maintenance of optimum soil fertility entails providing a supply of available potassium. Concentrations more than a few tens of mg/L is unusual except in water having high dissolved-solids concentrations. Biological factors may be important in controlling the availability of potassium for solution in rivers and groundwater. At times of relatively high water discharge, many streams carry potassium concentrations nearly as high as they do at times of low discharge. This may be the result of soil leaching by runoff.

Sulfate

Sulfur is commonly found as a component of sedimentary and igneous rocks in the form of metallic sulfides (Cusimano, 1991). Sulfides are oxidized upon contact with aerated water, producing sulfate ions in solution. Excessive levels in water may cause illness. The drinking water standard for sulfate is 250 mg/L. Beyond this point, sulfate levels may cause illness in humans. The combustion of fuel and ore-smelting processes are major anthropocentric causes of sulfate found in natural waters. Sulfides may also be present in soils that are oxidized through natural processes or organic waste treatment. Sulfate also occurs in evaporated sediments, such as anhydrite and gypsum. Excessively high sulfate readings are often associated with mine drainage. The oxidation of minerals like pyrite is the main culprit. High sulfate, as well as chloride concentrations, may be found in residual runoff from irrigated areas due to concentration of the runoff by evapotranspiration.

Iron and Manganese

Iron is an essential element in the metabolism of animals and plants. Although iron is the second must abundant metallic element on earth, concentrations in water are generally small. A recommended upper limit for iron in public water supplies is 0.3 mg/L. If present in water in excessive amounts, however, it forms red oxyhydroxide precipitates. Lower pH and higher iron concentration can occur in coalmine drainage water. Manganese is an essential element for both plant and animal life, and tends to deposit black oxide stains. It is an undesirable impurity in water supplies. The recommended upper limit in public water supplies is 0.05 mg/L. Manganese is often present to the extent of more than 1 mg/L in streams that have received acid drainage from coalmines (Cusimano, 1991).

Aluminum

Aluminum is an element that rarely occurs in solution in natural water in concentrations greater than a few tenths or hundreds of a milligram per liter (U.S.D.A, 1990). The exceptions are mostly water with a very low pH. The dissolved aluminum in water having low pH has a negative effect on fish and some other forms of aquatic life. Water having a pH below 4.0 may contain several thousand milligrams of aluminum per liter. Occasional reported concentrations of 1.0 mg/L or more, having a neutral pH, and no unusual complexion ions, probably represents particulate matter. Elevated aluminum concentrations have been observed in runoff and lake waters in areas affected by low pH precipitation.

Chloride

The value of chloride, for the purpose of water quality monitoring, is its role as an indicator substance. Traced to its source, it often leads to other more serious problems. Levels of 0-16 mg/L are considered normal, levels of 17-36mg/L are suspect, and levels greater than 36 mg/L are considered problematic. Levels above 400 mg/L may be toxic to aquatic life. Chloride is contained in rock and soil, the wastes of animals and is produced by the decomposition of dead organic matter. Sources of abnormal readings could be from street salting, sewage, failing septic systems, landfills, and various industries (Cusimano, 1991).

Water quality toxic substances indicators are as follows (Dennison, 1993):

Arsenic

A concentration of 0.05 milligram of arsenic per liter of water is safe. Thus, the standard level of arsenic in water for consumption should not be over 0.05 mg/L.

Zinc

Zinc is essential in plant and animal metabolism. Modern industry has several applications for zinc and has helped to distribute it in water supplies. Zinc can be considered an undesirable contaminant for some species of aquatic life 5 mg/L is considered the upper limit for zinc because it can be detected by taste above this limit. Concentrations in river water range from 5 to 45 mg/L. Water is not a significant source of the element in the diet of humans. It has about the same abundance in crystal rocks as copper or nickel, and is thus common. High levels in streams can mean that drainage from an acid mine is entering the stream.

Cadmium

Cadmium is categorized as a highly toxic substance. Even a small amount entering the human body can cause health problems. The concentration of cadmium should not exceed 0.0005 mg/L.

Chromium

Chromium is very dangerous to human beings. The concentration of chromium in water should not exceed 0.05 mg/L.

Cyanide

Cyanide is highly toxic to humans and has immediate effects on human health.

Lead

Lead is toxic to humans and is especially harmful to babies and pregnant women.

Mercury

Mercury is a highly toxic substance and has no beneficial effects for humans. It has adverse effects on the nerve system. The mercury existing in water for consumption should not be over 0.001 mg/L (Hygiene Division, 1999)

Biological indicators

Biological indicators are based on aquatic community characteristics that are measured both structurally and functionally (Washington, *et. al.* 1999). These criteria are used to evaluate the aquatic life. The principal biological evaluation tools used by Ohio EPA are indices of biological integrity that apply to fish and macroinvertebrates. These indices are based on metrics of species richness, trophic composition, diversity, presence of pollution-tolerant individuals or species, abundance of biomass, and the presence of diseased or abnormal organisms. Ohio EPA uses the results of sampling reference sites to set minimum criteria index scores for use in water quality standards. Biological indicators are detailed below.

Total Coliform and Fecal Coliform bacteria

The principal indicator of the suitability of water for consumption is total coliform and fecal coliform bacteria. Coliforms are found in human and animal feces, and are a good indication of bacterial contamination. Fecal coliform bacteria are microscopic organisms that live in the intestines of all warm blooded animals, and in animal wastes or feces eliminated from the intestinal tract (Cusimano, 1994). Fecal coliform bacteria may indicate the presence of disease carrying organisms that live in the same environment as the fecal coliform bacteria. The measurement is expressed as the number of organisms per 100 mL sample of water (100 mL). Fecal coliform bacteria samples should be collected by volunteers and brought to a certified laboratory. The fecal coliform samples need to arrive at the laboratory by the end of the sampling day unless other arrangements have been made. However, the fecal coliform samples will need to be tested within 30 hours from the time the first sample in the field was taken. All attempts should be made to get the samples to the lab on time. The laboratory should be called a day ahead of the actual sampling day, and on the day of sampling, to remind the laboratory when samples will be brought to them to be tested. (Coots, 1994)

Plankton

Plankton plays a key role in the ecological system and food chain. This is because plankton is a preliminary producer, and the types and quality of plankton present can help to identify the quality of water (Hygiene Division, 1999).

Benthos

Benthos is an animal without a backbone and lives in the ground or underground. This animal is the natural food of larger aquatic animals. It could indicate good water quality (Hygiene Division, 1999).

Other living organisms can also indicate the quality of water and some examples of these are now given.

Organisms that indicate water quality include aquatic insects and other animals, which have no back bone but need oxygen for respiration. These animals like to stay in clean water that has high levels of dissolved oxygen. However, many of them are able to adjust themselves to stay in places with low levels of dissolved, and some are able to stay in water with almost no dissolved oxygen. Thus, when there is pollution and the amount of oxygen in the water is reduced, some animals that require high levels of dissolved oxygen do not stay in that area of water. However, other animals are able to withstand such low levels of dissolved oxygen for longer.

Those requiring high dissolved oxygen levels include lay ascetic type I and various insects, while those requiring low dissolved oxygen levels are insects, shrimps, dragonflies, ribbed clams and oysters. Those relying on low dissolved oxygen levels includes lay ascetic type II, insects, shrimps and oysters. Whereas those having no backbone and wanting low oxygen are worm and earthworm (Foundation of Green World, 1999).

Related Data

Data related to water quality indicators worth mentioned here is stream flow or discharge. The stream flow, or discharge, is the volume of water passing a single point in the stream over time (Hayslip, 1993). It is measured by determining the cross-sectional area and velocity (speed and direction) of the flowing water. The measurement is usually expressed in cubic feet per second (cfs). Stream flow should be measured in the field and discharge results compiled in the office. Stream flow measurements should be at specific locations at the same time the other water quality parameters are sampled (Maidment, 1993 and Ellett and Mayio, 1990).

Water Quality Management

The concept of water quality management lies within the context of sustainable environmental management which emphasizes on continuous uses in a sustainable way within limits of carrying capacity of environment. The ultimate goal of water quality management is to achieve sustainable use of water resources by protecting and enhancing their quality while maintaining economic and social development. The process for water quality management encompasses many governmental institutions, private sectors, and local communities. To achieve water quality management goal, the active participation of stakeholders is a key for the success.

From Australia case in point, the process for water quality management involved the community working with the government to set and achieve local environmental values and water quality objectives for water bodies and to develop management plans for catchments, aquifers, estuarine areas, coastal waters or other water bodies. Management of water resources is mainly a State and Territory responsibility. The national guidelines was develop under the National Water Quality Management Strategy (NWQMS). It covers issues across the whole of the water cycle-ambient and drinking water quality, monitoring, groundwater, rural land uses and water quality, stormwater, sewerage systems and effluent management for specific industries. The aim of the guidelines is to help the community, catchment managers, environment protection agencies and water authorities protect water quality including development local action plans for water quality management (www.deh.gov.au/water/quality).

In case of Thailand, the Pollution Control Department (PCD) are responsible for water quality management. PCD was established on June 4, 1992 under the Royal Decree on the Organizational Division of PCD, Ministry of Science, Technology and Environment 1992, as a result of the Enhancement and Conversation of the National Environment Quality Act 1992. PCD's vision is to be an organization in which the society trusts and has confidence in the management of pollution for a better environment and a better quality of life. Their mission is to control, prevent, reduce and eliminate pollution and to conserve and rehabilitate the environment conducive for human life. Their duties are to submit opinions for the formulation of national policy and plans for the promotion and conservation of environmental quality with respect to pollution control, make recommendations for the establishment of environmental quality standards and emission/effluent standards, develop environmental quality management plans and measures to control, prevent, and mitigate environmental pollution, monitor environmental quality and prepare an annual report on the state of pollution, develop appropriate systems, methodologies, and technologies for the application in the management of solid waste, hazardous substances, water quality, air quality, noise level, and vibration, coordinate and implement measures to rehabilitate and remedy damages caused by pollution in the contaminated area and environmental damage appraisals, provide assistance and advice on environmental management, cooperate with other countries and international organizations on environmental management, and investigate public complaints on pollution.

The emission and effluent standards are established for pollution control from point sources in order to meet the ambient environmental quality standards. The standards in accordance with this Act are the national minimum standards. Any locality that is affected by pollution and has potential health or economic damages shall be designated by the National Environment Board as a pollution control area in order to receive priority in the budgeting process and in remedial action plans. Moreover, local officials are authorized as the pollution control officials according to this Act. The local authorities are the ones who are prepared and are responsible for taking action on their own provincial environmental management plans through the annual budgeting process.

Database Management

Data and information is so important in most organizations in our information-based society. With accurate and timely data information, people in organizations make better decisions and respond more confidently to organizational change, their responsibilities, and society demand. Watershed management has no exception. Knowledge and updated information regarding the resources and their functions within watershed is crucial to understand the watershed comprehensively and give appropriate guidelines for implementation to meet watershed management goals.

Data is defined as the recorded values of an attribute or parameter. They are raw measurements of facts, often made by instruments or collected by field staff. Data forms the basis which information is created upon (Keith, 1995). Data are raw facts which indicate that facts have not yet been processed to reveal their meaning (Rob and Coronel, 2002).

There is now rather widely accepted distinction between data and information. Data is raw measurements of facts while information is considered a derived form from data and useful in problem solving (Adrian, 1963). In other words, information is produced by processing data so that decisions can base on.

It is obvious that timely and useful information requires accurate data. Such data must be generated and stored properly in a format that is easy to access and process. Data management is a discipline that focuses on the proper generation, storage, and retrieval of data. Typically, efficient data management requires the use of a computer database (Rob and Coronel, 2002; and Malaiwong, 1997).

Rob and Coronel (2002) and Silberchatz *et al.* (2002) define database management system (DBMS) as a collection of interrelated data and a set of programs that mange the database structure and control access to the data store in the database. The primary goal of a DBMS is to provide a way to store and retrieve database information that is most convenient and efficient. The database system has four components: data, hardware, software, and peopleware. Hardware functions on data input and processing. Software is used for management database. Peopleware functions as users of the database which divided into three categories: programmers, general user, and management of the database (Teneasara, 2000).

The application of a database in the processing system can generate many benefits as follows (Davis and Olson, 1985):

1) To reduce redundancy and avoid inconsistency of data. Since the data collection is kept in the same database, it is convenient to control redundancy.

2) To share ability in data use. Since the data is kept in separation from other programs, the use of data could control the standard and transform such data between the systems conveniently and correctly. In this regard, the database administrator will control the system and determine the standard of data, through designing the structure

and type of data being transferred from one system to the other. This would help maintain the database and integrity of data as well as examining for correctness and mistakes, and reducing application development time. The database also has some facilities to make the concerned work easier and can reduce the normal time required as well as provide system security through the protection of rights for users.

3) To make a balance in the conflicting requirements of data.

Database Development Approach

The System Development Life Cycle approach (SDLC) in database development process is an orderly stepwise and workable system (Everest, 1986). It comprises of 3 steps:

1) the system analysis: to study the existing database system, problems of the system, and needs of database,
2) the analysis and design of the new database system: to analyze the needs of the new database from database users in order to design the database accordingly, and
3) the development and set up of the new database to implement and test the new database and modify it to ensure the system efficiency.

People Participation

Chongwootiwed (1984) defined participation broadly: "It refers to one's mental and emotional behavior expressed in [a] group situation, hoping to achieve the goal of that group. That behavior will cause (a) feeling of responsibility with (the) group later." Additionally, many scholars (Whuthemaethee, 1983 and Mingmaneenakhin, 1988) defined the meaning of participation in the context of development.

Therefore, people's participation in environmental management can refer to the population's behavior regarding environmental management to be congruent with community needs. There are many ways of expressing participation such as being a leader or a creator, problem and cause finding, sharing opinions for management planning, sharing implementation and responsibilities of environmental activities and improving and maintaining environmental quality.

People participation may be achieved in many ways. Mostly, it is achieved through activities that determined or created by government. However, many scholars have suggested similar ways of participation in development, as follows (Dhacharin, 1984; Suwanmongkhol, 1984; Mingmaneenakhin, 1988; and Ninphanich, 1989):

1) Participation in studying and analyzing the community in order to perceive the problems and needs of the community, setting the priority of each problem and selecting the problem to be corrected according to priority of importance.

2) Participation in analyzing the cause of the problems in order to solve the problems directly.

3) Participation in choosing and planning the solution to each problem in order to have principles of ordering the problems and the steps involved in solving each problem.

4) Participation in implementation can cause people to pay attention to their activities and give them a sense of ownership.

5) Participation in follow–up activities aimed at determining progress and achievement. Such activities include gathering information regarding resource usage, the implementing technique, data processing, including problems and obstacles analyzing in order to determine the advantages and disadvantages of implementation and to improve activities to achieve goals effectively.

However, people participation should be self-initiated. Chomdee (1991) and Chongwootiwed (1984) proposed a participation pattern with a leader or creator. When people have a leader or creator in their activity group, the group arrangement and the participation process will occur. Then those initially outside the group may participate with supporting activities. People can have different roles to play such as donating money, software and device support, persuading neighbors and conducting public relation excercises to promote more public participation (Chongwootiwed, 1984; Makarapong, 1988; Chomdee, 1991; and Rachanipawan, 1992)

People Participation in Environmental Management

The effective environmental management should give people more opportunity to participate by allowing people to be leaders or creators. This shows that they are ready to solve problems. After they have participated in problem determination, cause finding and management planning, they are able to draw up a guideline for solving the environmental problems that is congruent with people's needs. When successfully implemented, this process results in willingness and readiness to participate in those activities. People should also participate in the evaluation process in order to consider and accept the advantages and disadvantages from their own actions and will result in their readiness to improve activities in the future.

Form the literature review on participation in environmental management, many works have studied only participation in practicing activities (Phorchai, 1993; Yothamat, 1996; and Narakhon, 1998). The related research on participation in environmental management that can be classified into two groups: (a) natural resource management where participation was mostly found in practicing steps (Chemcharien, 1988); (b) pollution elimination where participation was found only in promoting activities because the pollution problems were too complicated and too difficult to understand for local people to participate in.

Factors Affecting Participation

Social theories are introduced to explain people's participatory behavior as follows:

Knowledge

According to the definition of education, "knowledge" means the facts, truth, criteria and other data that are collected from various experiences (Good, 1973). The meaning of knowledge, as defined in the Lexicon Webster Dictionary, 1997, is what is involved with facts, criteria, and structures, which are the result of study and research, or knowledge related to places, things or persons that are obtained from observation or report. This kind of knowledge needs time to generate. Bloom (1971) and Kedsing (1987) defined the meaning of knowledge to be that which is involved with the recognition of particular issues or general matters regarding methods, processes or situations, with particular attention to memory.

It can then be concluded that knowledge resides in the cognitive domain with the expressions of learning, memory, recognition regarding facts, criteria, principles, theories, events, individuals, experiences, research and questions. It takes time to collect knowledge.

Bloom (1971) divided knowledge or cognitive domain into knowledge that is learnt with regard to memory and is the recognition of ideas, objects, and phenomena. It starts from simple things that are independent and develops to complex memory, which is interrelated. Comprehension is a cognitive domain related to communication in terms of translation, interpretation and prediction. Application is an ability to function in new situations. Analysis is an ability to classify objects of contents into small parts which are associated and to seek the interrelationship among the parts. Synthesis is the ability to consolidate big and small parts into a whole. Evaluation is the ability to make decisions based on values, thinking, methods, and contents in order to achieve some objectives, based on some criteria. It is the highest level of conceptual development and is built upon abilities involved with knowledge, understanding, applying, analyzing and synthesizing. The evaluation may relate to emotion, intention and feeling, especially for intellectuals.

The instruments for measuring knowledge are varied in line with different characteristics. The most popular instruments include tests, question items, or others arranged for introducing any person or group who express behavior or response. Such behavior or response can be observed or measured (Kedsing, 1987).

The analysis of action

The analysis of action is a psychological theory describing the cause of people's action. Lumsdaine (1995) explained that the causes of behavior were classified into two types: personal cause, and environmental condition cause. These causes were relatively increased or decreased.

The theory of Social Action

Srisanat (1999) explained that human action depended on two factors: individual personality and social culture. Culture is the determinant of ideas, beliefs, primary interests and system of beliefs.

Theory of Social and Cultural Change of Community

Srisantisook (1993) suggested that two factors affecting social and cultural change of the community:

1) factor inside community: such as community ecology, people's acceptance of new things and people's personality in the community, education gender, age, working experience and leadership.

2) factor outside community: such as cultural diffusion between community, mass communication, radio, television, other telecommunications and basic infrastructure.

According to these theories, it can be seen that people's participation is based on many factors including personal and environment stimulating factors. Many works described factors affecting people's participation and they depend on geographical condition, economic status, political, social and culture of the community. These factors influenced people's readiness to participate in different ways. Walaisatien *et al*. (2000) concluded the six social and psychological factors that influenced the participation are shared of interest and concern, shared troubles and dissatisfaction, shared agreement to change group behavior in a desirable way, acceptance of the usefulness of participation, freedom and time to participate, and motivation from group success.

As mentioned above, both personal factors and societal environment are important for the participation of people in environmental activities and the maintenance of environmental quality in the community. Ten variables were identified.

1) Gender: Males and females are different both physically and mentally. Males have firm and stable thinking, pay attention to themselves more than environmental conditions and prefer competition. In contrast, females pay more attention to environmental conditions and prefer to create a friendlier atmosphere than males (Pinthapath, 1989). These aspects affect a person's personality, attitude, viewpoint and behavior. According to many research works, it has been found that gender is significantly related to people's participation. Males participate more than females (Phansri, 1999). But some studies have showed that females have participated in environmental activities more than males (Narakhon, 1998).

2) Age: Age is a determinant of a person's personality including expertise, skill, responsibility, interest and problem solving ability. It can be seen that adults have higher emotional maturity than children. As a result adults take more reasonable and appropriate action. In addition, mental development changes according to age. In

childhood, individuals are always concerned with personal benefit, while they become more concerned with public benefit when they grew up (Pinthapath, 1989). So, at different age levels, individuals act differently. According to many research studies, it has been found that different age levels cause different levels of participation significantly (Somsa-art, 1995). Groups who with older members participated more than others (Yothamat, 1996; and Phetcharunan, 1996).

3) Educational level: Education can make one develop knowledge, change perspective, and act for societal advancement (Wiriphiromkul, 2000). Highly educated persons tended to understand and accept change easier than low educated persons. Many related research studied on the relationship between education and people’s participation have showed that groups with different educational levels have had different levels of participation (Somsa-art, 1995). The higher the educational level, the more participation in the activity.

4) Occupation: Persons who work in a particular occupation have developed their own set of rules and order to live by Wiriphiromkul (2000). This makes a person in each occupational group show different kinds of activity and determines that person's relationship with society according to that occupation's characteristics (Horayangkul, 1992).

5) Income: Income is an index of socioeconomic status (Thimasan, 1995). Economic status reflects the differences in people’s living conditions (Pinthapath, 1989) For the high income family, the housewife would spend money instead of doing housework and as a result she has more spare time to do other activities (Thumkrachang, 1986). Those with a high income always have a better quality of life and have enough spare time to dedicate themselves for the public good. According to research studies, there is a significant correlation between income and people’s participation (Somsa-art, 1995); and Yothamat, 1996). Research work done by Wiriphiromkul (2000) concluded that there was a relative difference between income level and participation in community forest management.

6) Membership of the social group: When persons enter a group of activity, they can give their opinions and make decisions, and also develop interpersonal relationships in the society. As a result, they can form attitudes (Phansri, 1999). Therefore, participation in the community could form their behavior. Many research works have shown that being a member of different groups or organizations causes different levels of participation. Those who were a group’s member in society participated more than those who were not a group’s member (Yothamat, 1996; and Wiriphiromkul, 2000).

7) Social status: When persons live together in society, structure and functions are formed. A person's function is determined according to their status. So, status is a determinant of people’s behavior in the society and should be congruent with their social role (Horayangkul, 1992). Research regarding the relationship between social position and participation has found that having different social positions can cause

different levels of participation. The higher the social position the more participation in groups

8) Environmental Information Perception: Perception is directly related to the way in which a person thinks about the environment and this in turn determines their behaviour. When a person perceives any subject, they will make a decision to respond to the perceived subject (Wiripiromkul, 2000).

9) Environmental Knowledge: Learning can evoke new ideas and lead to changes in opinion. However, a person's learning depends on their interest and ability to comprehend and accept knowledge. The experience of learning will create a positive attitude toward that thing. When attitude changes so will behavior (Chan-aim, 1979). From many research studies, it was found that possession of different levels of environmental knowledge caused different levels of participation. Members of groups with higher levels of knowledge participated more in activities (Somsa-ard, 1995; and Narakhon, 1998).

10) Attitude towards the Environment: Attitude is an abstract feeling which is generated from a person's learning, objectives and situation in society. A person's feeling and perception of anything influences their behavior. If they has a positive attitude towards things, they value them and act towards them positively (Chan-aim, 1979). Therefore, attitude is a determinant of how or what an individual does. According to many research studies, it can be concluded that having different attitudes might cause different levels of participation. The more positive the attitude toward the environment, the more participation in activities. (Phorchai, 1993; Narakhon, 1998; and Northern development foundation, 1998)

Participatory Action Research

Creation of a database or information system by a Participatory Action Research (PAR) or Action Research (AR) has been carried out for some time in business enterprises and adult learning (Jonsonn, 1991; Trauth and O'Connor,1991, Kock and McQueen.1995; Liang, and McQueen, 2000). Action research has been considered a distinctive form of research since the 1940s. Kurt Lewin was the first person to use the term "action research" to refer to a specific research approach in which the researcher generates new social knowledge about a social system, while at the same time attempts to change it (Lewin, 1946; Peters and Robinson, 1984).

To understand the nature of AR, Kock, McQueen, and Scott (1997) explained that AR involves research intervention in real life contexts in order to both improve those contexts and, at the same time, generate relevant scientific knowledge (Jonsonn, 1991; Peters and Robinson, 1984). That intervention may target core business improvements, such as overall competitiveness, or more limited improvements, such as building or expanding the existing learning skills of the organisation (Elden and Chisholm, 1993; Whyte, Greenwood and Lazes, 1991). This improvement-oriented characteristic of AR is based on the belief that the researcher's positive intervention fosters involvement, co-operation and information exchange with organization members, which in turn leads the researcher to a deeper understanding of the context being observed (Fox, 1990; Gustavsen, 1993). Typical example is the study of asynchronous groupware support effects on process improvement groups conducted in a service organization by Kock and McQueen (1995).

Susman and Evered (1978) view a general AR project as a cyclical process carried out through what these authors refer to as the AR cycle (Figure 1), comprising five stages: diagnosing, action planning, action taking, evaluating, and specifying learning. The diagnosing stage involves the identification and definition of an improvement opportunity or a general problem to be solved in the client organization. The following stage, action planning, involves the consideration of alternative courses of action to attain the improvement or solve the problem identified. The action taking stage involves the selection and realization of one of the courses of action considered in the previous stage. The evaluating stage involves the study of the outcomes of the selected course of action. Finally, the specifying learning stage involves the study of the outcomes of the evaluating stage and, based on this study, knowledge building in the form of a model describing the situation under study. Initially this model is expected to be only descriptive, rather than predictive, since the deep involvement of the researcher with the environment being studied leads, due to time constraints, to the study of a small number of instances of particular events. However, as the number of AR studies carried out on a similar topic grows, their resulting descriptive models can then be integrated into more general and predictive models, and eventually lead to "grand theories" (Strauss and Corbin, 1990). The contemporary approaches to AR, such as PAR, strive for the full involvement of the client organisation in all stages (Elden and Chisholm, 1993).

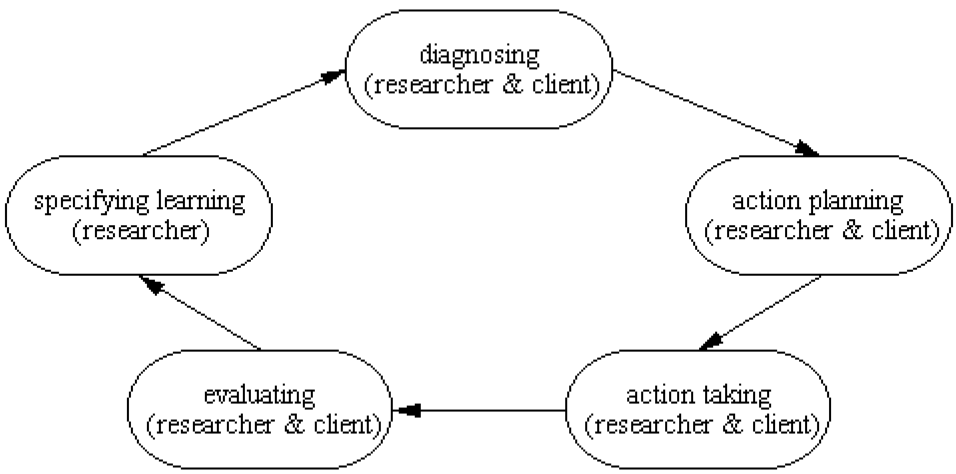

Figure 1 The AR Cycle (Susman and Evered, 1978)

Participatory Action Research employs several social techniques in its research process. Appreciation-Influence-Control Techniques (AIC) and Social Learning Process (SLP) are the common ones applied at present.

<u>Appreciation-Influence-Control Technique</u> (AIC)

Appreciation-Influence-Control (AIC) is a technique to brainstorm the opinion of the people in the community for planning the community development. It is a potential technique in building power and creating the acceptance of villagers in thinking and planning for community development by their own (Walaisatien, *et al*. 2000). AIC is developed from the conceptual idea of Organization for Development: an International Institute (ODII). This technique has been tested and disseminated in Thailand, with collaboration of ODII and Thailand Development Research Institute (TDRI) It is found that the AIC technique is a political process for building power and creating acceptance among villagers of community development. It focuses on the conceptual framework and participation of members of the community and is based on the principle of equity. Thus, it is a human-centered process for development.

<u>Social Learning Process</u> (SLP)

Social learning process (SLP) is a conceptual idea, which has been designed in the development of the quality of life for the people in northeastern region of Thailand. This activity is part of a project implemented by the Department of Informal Education (Walaisatein *et al.,* 2000). The SLP process focuses on learning by the people. At each stage, those concerned may apply methods for creating knowledge through various techniques such as brainstorming and group discussion.

SLP is a learning process to search for and scope problems, through the same process as the action research. According to this concept, it is believed that when the people are able to use this process in tackling problems in their own lives, families and community, they can manage such problems by themselves. It is regarded as a guideline for developing both their own quality of life and that of their community.

<u>Relevant research</u>

<u>Relevant research to the computer program</u>

Modisette (1980) performed a research on the use of the computer to teach high school mathematics. The objective was to compare the 2 methods of study, one of them was the use of computer program and the other was by reading from textbooks. The results of the research showed that the students used the computer program had a higher ability to computer mathematical problems than those studied from the textbook.

Oden (1981) conducted a research to compare 2 method of study which were using the computer program and the other was by listening to lecture given by teachers. The research was conducted on grade 9 students who were taking mathematics. The results of the research showed that the students that used the program for learning had higher abilities to computer mathematics than those just listened to the lectures given by their teachers.

Merritt (1983) performed a study to find out the efficiency of learning by using the computer program and by using the original way of study and then compared these two methods together. The sample group consisted of students in middle class school who were studying mathematics. The results of the research proved that the group which used the computer as an educational aid was able to learn mathematics more efficiently than those that did not.

Turner (1983) conducted a research to compare 2 different teaching programs. Seventy teachers cooperated in this research, they were divided into 2 groups; each group consisted of 35 persons. These teachers were learning how to teach their students to read properly. One of the groups learned their lessons from computers whereas the other group studied in the orthodox way of reading from textbooks. The results of the research showed that the achievements in the study of the two groups were not different statistically. Nevertheless, mentally, the teachers that used the Computer Aided Instruction (CAI) program for learning had better attitudes towards the subject they had to study than those that had t use the orthodox way for learning.

Quaddus (1997) studied about the learning and practices of multiple criteria decision making (MCDM) had grown rapidly over the recent years. This research presented an integrated system called MOLP/PC for the learning of various MCDM tools for the real world decision making. The MCDM area describes the system via a realistic MCDM problem with actual screen displays. The results of an empirical test to measure the effectiveness of MOLP/PC. The system was interactive, extremely user friendly and operates around a custom built spreadsheet. The demonstrates of MOLP/PC had been used over the last several years to facilitate the learning of MCDM at the tertiary levels in Singapore, Sydney and Perth.

Joiner *et al.* (1999) studied about the involving 65 children (31 boys and 34 girls) aged between 10 and 11 years, which further examined the effect of software type by comparing children's performance on a male stereotyped version of the software with their performance on a structurally identical, but female stereotyped version of the software. We found that girls performed worse than boys on both versions of the software and this effect persisted even when the effect of computer experience was removed. There was also a gender difference in the children's preference. Girls preferred the female version to the boys and there was also a significant relationship between the girls' preferences and their performance. There was no relationship between the boys' preferences and their performance.

Washington *et al.* (1999) studied a CAI tool that expedites the transition from lecture to application for students in an introductory biomechanics class. It contained a review of basic concepts of rigid body mechanics and functional anatomy and combines them in a way that the student can become confident and efficient in building biomechanical models. The tutorial was used by juniors and seniors. The Biomechanics Tutorial (BT) contains mechanics and anatomy reviews and quizzes, quiz results, examples of simulations, a study guide, and practical anatomical simulations that were presented as laboratory exercises for students to explore and analyze. The researcher conducted an objective evaluation using statistical analyzed and a subjective evaluation using student questionnaires to assess the tutorial as an instructional aid that accompanied the professor's explanations of basic mechanics and functional anatomy concepts. Pre-tutorial mechanics quiz scores indicated that 86% of the students did not have sufficient mastery of mechanics concepts. The BT significantly ($p<0.05$) improved the performance on the post-tutorial mechanics quiz. A regression model used to test the effect of the tutorial on final grade while controlling for confounding factors (i.e., GPA and prerequisite classes), did not show that the BT significantly improved the final grades between the control and treatment groups. Students felt the BT was successful in helping them to better understand the principles of industrial ergonomics. This evaluation of the Biomechanics Tutorial was a contribution to the limited amount of research that shows a positive effect of CAI on college student achievement.

Relevant research to the participatory approach

Balcazar *et al.* (1998) studied about the participatory action research (PAR) provided a framework in which people with disabilities can take an active role in designing and conducting research. This approach provided individuals with disabilities an opportunity to re-shape the rehabilitation research agenda and empowers them to address their independent living and rehabilitation goals. Four principles of participatory research were discussed, including (1) the active role individuals with disabilities play in defining, analyzing and solving identified problems; (2) the opportunities for more accurate and authentic analysis of people with disabilities; social reality; (3) the resulting awareness among people with disabilities about their own resources and strengths; and (4) the opportunities for improving the quality of life of people with disabilities. The output showed that some of the challenges of conducting participatory research, including the need for researchers to relinquish some of the control of the research process, the duration of the procedures, the difficulty of recruiting participants, and possible unintended consequences of the research process. Although not without difficulties, the potential contributions of PAR to understanding of the fundamental issues faced by people with disabilities are substantial.

Corbon, (2002) conducted the environmental management decision-making, its methods and assumptions had been criticized for, among other things, perpetuating environmental injustice. The justice challenged to risk assessment claim that the process ignores the unique and multiple hazards facing low-income and people of communities and simultaneously excludes the local, non-expert knowledge which could help capture these unique hazards from the assessment discourse. This research conventional risk assessment and suggests that traditional models of risk characterization will continue to ignore the environmental justice challenges until cumulative hazards and local knowledge were meaningfully brought into the assessment process. Whether a shift from risk to exposure assessment might enable environmental managers to respond to the environmental justice critiques. The US EPA's first community-based Cumulative Exposure Project, piloted in Brooklyn, New York, USA, and extent this process addressed the risk assessment critiques raised by environmental justice advocates. This research suggested that a shift from risk to exposure assessment can provide an opportunity for local knowledge to both improve the technical assessment and its democratic nature and may ultimately allow environmental managers to better address environmental justice concerns in decision-making.

Aerni (2004) studied about stakeholder attitudes towards the risks and benefits of genetically modified crops in South Africa. The attitudes and interests of stakeholders involved in national public debates on the risks and benefits of genetically modified crops were a significant influence on public opinion as well as public policy outcomes related to the use of genetically modified organisms (GMOs) in agriculture in developed and developing countries. This article discussed the results of a perception survey conducted with South African stakeholders involved in the GMO debate in 2000 and uses them to explain GMO policy in South Africa in 2004. The results suggested that academia, government, producer and consumer organizations and industry in South Africa strongly believed in the benefits of GMO crops, while non-governmental organizations and churches did not. Instead, the latter emphasize the potential risks that, they claim, the government did not address with its permissive policy toward GMOs. The paper concludes that South Africa has become an African leader in promoting as well as in opposing modern biotechnology in agriculture. At the same time, the domestic debate on GMOs continues to be very polarized. The South African government might reassume public leadership by designing a biotechnology policy that aims at minimizing the risks and maximizing the benefits of the technology not just in terms of economic growth but also environmental conservation and poverty alleviation.

Cockeril *et al.* (2004) conducted a solid body of research on both collaborative decision-making and on processes using models; this research was general public attitudes about models and their use in making policy decisions. This research assessed opinions about computer models in general and attitudes about a specific model being used in water planning in the Middle Rio Grande Region of New Mexico, USA. More than 1000 individuals were surveyed about their perceptions of computer-based models in general. Additionally, more than 150 attendees at public meetings related to the Middle Rio Grande planning effort were surveyed about their perceptions of the specific Rio Grande-based model. The results revealed that the majority of respondents were confident in their ability to understand models and most believe that models were appropriate tools for education and for making policy decisions. Responses developed a model was a key issue related to public support. Regarding the specific model highlighted in this project, the public revealed tremendous support for its usefulness as a public engagement tool as well as a tool to assist decision-makers in regional water planning. Although indicating broad support for models, the results did raise questions about the role of trust in using models in contentious decisions.

Clerici *et al.* (2004) achieved improved sustainability, local authorities need to use tools that adequately describe and synthesize environmental information. This research illustrates a methodological approach that organized a wide suite of environmental indicators into few aggregated indices, making use of correlation, principal component analysis, and fuzzy sets. Furthermore, a weighting system, which included stakeholders' priorities and ambitions, was applied. As a case study, the described methodology was applied to the Reggio Emilia Province in Italy, by considering environmental information from 45 municipalities. Principal component analysis was used to condense an initial set of 19 indicators into 6 fundamental dimensions that highlight patterns of environmental conditions at the provincial scale. These dimensions were further aggregated in two indices of environmental performance through fuzzy sets. The simple form of these indices made them particularly suitable for public communication, as they condensate a wide set of heterogeneous indicators.

Community river quality information to the public using a graphical indicator approach

The Rouge River and its urban watershed near Detroit were primary sources of pollution to the Great Lakes (Smith, V. E. 1997). The Rouge River Wet Weather Demonstration Project, conducted by Wayne County, Michigan, and funded by grants from EPA, was designed to restore Rouge water quality and public use. The project mission also included demonstrating solutions to water quality problems facing urban waters, which were highly impacted by wet weather loadings of pollution. The Rouge Project was expected to provide other municipalities with potentially useful approaches and methods for dealing with similar problems of Combined Sewer Overflows (CSOs), storm water and other non-point sources of pollution. This included demonstrating creative public involvement and education programs. One of the main public issues concerning the Rouge River was how water quality conditions affect its recreational and aesthetic uses. Throughout the past three years, Rouge Project staff produced an abundance of technical information on river and watershed quality. Project staff gained some practical insights which could be expressed in fairly simple terms. Recently staff had explored the "quality indicator" approach as a tool for reporting technical information on river quality to the interested public. Such indicators represent only selected features of the whole database, but, ideally, they were key markers of river quality. Another premise of the indicator approach was that condition quality affects use quality. An important goal of Rouge reporting was to make the public aware of the linkage between river conditions and uses.

Staff of the Rouge River National Wet Weather Demonstration Project (Wayne County, Michigan) have developed a graphical indicator approach for reporting river quality information to the public. The information consisted of measurement data and observations of chemical, biological and physical indicators collected during 1994-1996. The quality indicators included three factors (dissolved oxygen, flow and bacteria) and two indexes or factor composites (aquatic life and stream habitat). Indicator results for sites throughout the Rouge watershed was represented by color-coded icons linked to sites on sub-watershed maps. Icon colors indicate three ranges of condition quality: good, fair and poor. There were four common categories of public use: fishing; canoeing & boating; wading & swimming; aesthetics (other enjoyment). Similar color codlings along the river lines indicated three ranges of use quality (Heidtke, 1996).