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*The Use of Fertilizers in Aquaculture  
in China*

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**Preface**

**China is the largest country in the world for aquaculture**

- Total output in 2012: 59 million tons (49 M t in 2004), accounted for 70% of the world total.
- Field Area in 2012: 8.08 million hm<sup>2</sup>
- Fish species :over 160 of which 100 are marine species and the remaining 60 species are fresh water

The use of fertilizers for fish farming has grown dramatically in the fast-growing aquaculture industry in China. It has been a common practice that farmers apply fertilizers together with feedstuff as an economical means to raise fish yield.

**This paper is prepared to address the use of fertilizers in aquaculture in China**



## I. Principles and functions of fertilizer use in fish farming



### Water quality parameters in *aquaculture*:

**Nutrient contents, depth, temperature, pH value, oxygen and the types of salts and their concentrations in the water. The control of water quality is an important process for high-yielding fish farming.**

### Goals of applying fertilizers to the fishponds :

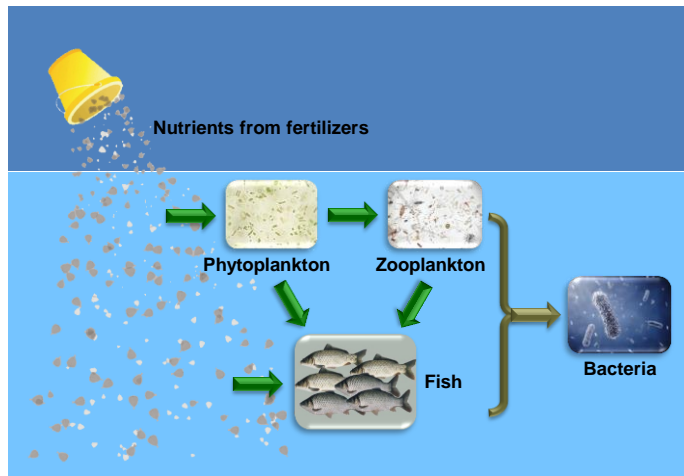
enrich the “poor water” to become “fertile water”

### The use of fertilizers in fish farming plays the following roles:



- To enrich the water fertility by increasing the nutrients and organic matter in the water, some of which can become the feeders for fish directly
- To stimulate the growth and reproduction of planktons, algae, and zoobenthos etc in the water, which form the natural diets for fish

## Basic Food Chains in Fishpond



## The functions of the fertilization for fish farming



- Some organic and inorganic nutrients from the fertilizers become the feeders of the fish
- The majority of the nutrients from fertilizers provide nutrient source for green plants, algae, and autotrophic bacteria etc., which are among the direct sources of food for fish
- The green plants become the food of lower-grade animals, which in turn is the food for fish



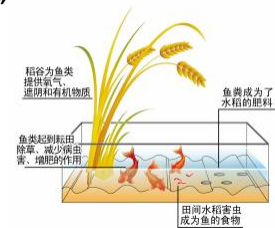
## II .The history of the fertilizer use and its consumption in fish farming in China

China has a long history in the use of organic fertilizers in fish farming, dating back to more than 3,000 years ago

### Records:

- “The Scriptures of Fish Farming” 2400 years ago
- “The Records in Ling Nang” in late Tang Dynasty regarded as the prototype of fish farming in China’s history and evolved to “rice-fish-farming technology” listed in the agricultural heritages of the world.

J.B. Lu, X. Li. Review of rice–fish farming systems in China—One of the Globally Important Ingenious Agricultural Heritage-Systems (GIAHS), *Aquaculture* ,260(2006)106-113



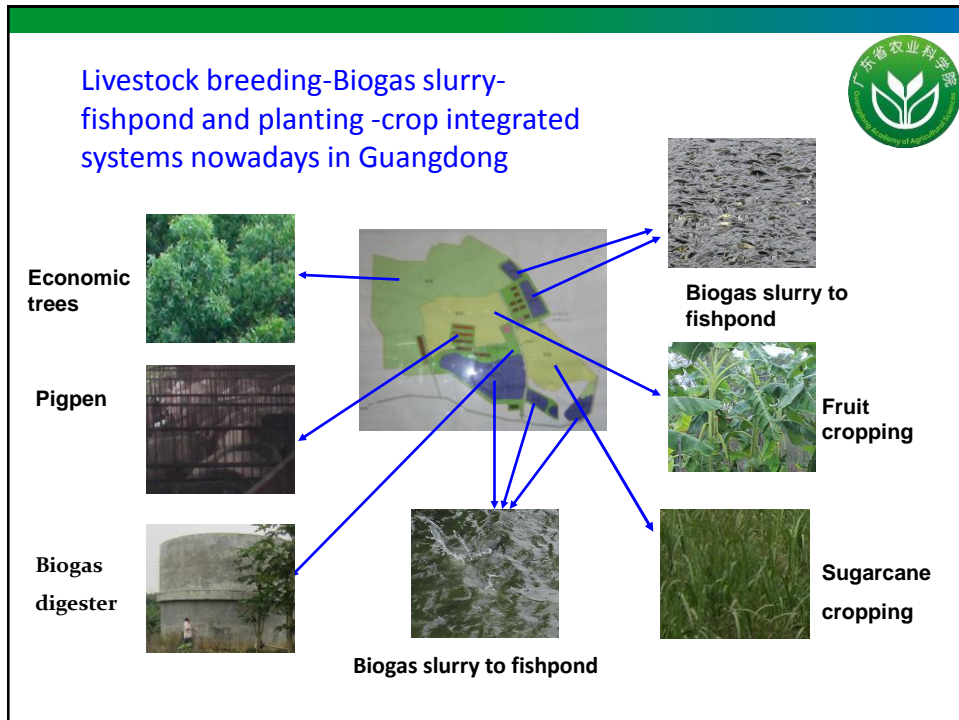
## Other important ecological fish farming



“mulberry-base- fishpond”, an important fish farming system in the Pearl River Delta regions in Guangdong; also known systems are “sugarcane-base- fishpond”, “fruit crop-base- fishpond”, etc.



G.F. Zhong, Some problems about the mulberry-dyke-fish-pond ecosystem on the Zhujiang delta [J]. *Chinese Journal of Ecology*, 1982 (1): 10-13 (in Chinese).



**The history of chemical fertilizers use in fish farming is relatively short.**

- **Research began in 1972** by the Institute of Hydrobiology
- **Research** expanded to many Chinese provinces **in 1980s**
- **The use of fertilizer** as a major practice accepted by fish farmers since 1990s

The Guangdong Academy of Agricultural Sciences logo is in the top right corner.

## Estimated consumption of fertilizers in aquaculture in China



Some researchers tried to estimate the consumptions.

Regional investigations by Ou *et al* :

The input of fertilizer to the Datong lake, the internal part of Dong Ting Lake, was 7000 t (612 kg/hm<sup>2</sup>) in 1999, of which 40% as P<sub>2</sub>O<sub>5</sub> and 60% as N and increased to 8000 t (700 kg/hm<sup>2</sup>) and 8500 t (744 kg/hm<sup>2</sup>) respectively in 2000 and 2001.

F.P. Ou, *et al* Ecological environment situation and its remediation measures of the Dong Ting Lake . Inland Fisheries 2003(12):73-76(in Chinese).

Estimation for the consumption by Li *et al* in 2001 only according to areas :

The increments of fertilizer in aquaculture were 0.337 to 0.844 million t from 1998 to 2028; if the fertilizer application area increased by 20% to 50%. According to the data, the calculated fertilizer consumption in aquaculture was about 1.685 million t in 1997.

J.K. Li, *et al* .Prospect of consumption of chemical fertilizer in China. Plant Nutrition and Fertilizer Science, 2001, 7 (1): 1-10 (in Chinese).

J.K. Li, *et al* .Dissecting the perspectives of fertilizer application in China. Phosphate & Compound Fertilizer, 2001, 16 (3): 1-5 (in Chinese).



Up till now, there are no official statistics of fertilizer consumptions in aquaculture industry in China. It is very hard to collect the data of fertilizer amount applied in fishery, we try to estimate the consumptions of chemical fertilizers in fish farming based on the areas of fish farms and fish output. Because marine fish culture rarely uses fertilizers, only the fertilizer consumptions in fresh water fish farming are estimated.

# Methodology



The fresh water fish farming is divided into four groups : 1.pond farming 2.lake framing 3.reservoir farming 4. river farming



Collecting the data of fish area in  $\text{hm}^2$  (S1, S2, S3 and S4 ) and fish yield in  $\text{ton}/\text{hm}^2$  (M1, M2, M3 and M4) from the China Agriculture Yearbooks during 1990 to 2012 yearly



Some parameters: **The fertilizer requirements (r): 0.14 kg N for 1 kg of fish products**

0.35 kg of N (contributed by feed, water, bottom mud, fertilizer applied) was needed in increasing 1 kg of fish production, the rate of contribution of fertilizer to N is about 40%. So  $0.35 \times 0.4 = 0.14$ .

**The Benchmark fish yield (b) :the maximum fish yield when fertilizers are not applied. In groups as  $b_1 = 2 \text{ t}/\text{hm}^2$ ,  $b_2 = 0.35 \text{ t}/\text{hm}^2$ ,  $b_3 = 0.25 \text{ t}/\text{hm}^2$  and  $b_4 = 0.6 \text{ t}/\text{hm}^2$**

**The correction factor (e) :  $e = 1$  (before 1998),  $e = 0.90$  (1998 -2004) and  $e = 0.85$  (after 2004)**

according to the situation of water eutrophication or the restriction degree to fertilizer application in fish water fields related to water sources by local government.



**The annual N consumption (EAN, in 10,000 t)**

$$\text{EAN} = [S1 * (M1 - b_1) + S2 * (M2 - b_2) + S3 * (M3 - b_3) + S4 * (M4 - b_4)] * r * e / 10000$$



The annual  $\text{P}_2\text{O}_5$  consumption (EAP in 10,000 t) :

$\text{EAP} = \text{EAN} / 3.5 * 2.29$  of which 3.5 represents the average application ratio of N to P and 2.29 the coefficient for P converting to  $\text{P}_2\text{O}_5$ .



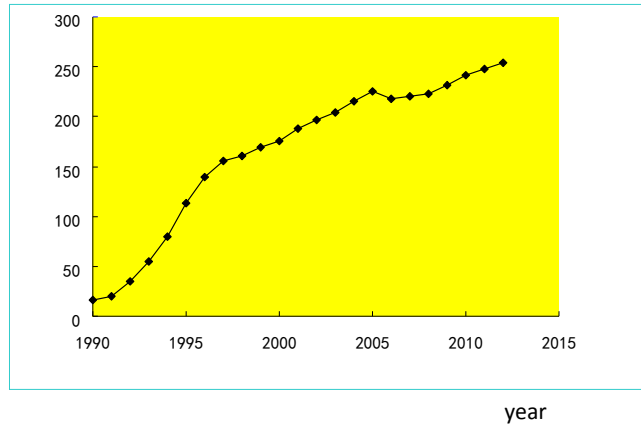
The estimated annual fertilizer consumption:  $\text{EAN} + \text{EAP}$

**The estimation considers the fish farming area, the fish yield in  $\text{hm}^2$ , the N requirement of fish and the contribution of N fertilizer, Benchmark fish yield and some restricted factor by water quality and law factor.**





Consumption (Net nutrient) in 10000 t



**1970 to 1989** :in the phase of research and development, fertilizers consumed in fish farming were less than 150,000 tons

**1990 to 1997**: In 1997, nearly 0.98 million tons of fertilizers were consumed in fish farming, 5.9 times of the number in 1990, an increase by 38.5% year on year.

**1998 to 2005** :The growth of fertilizer is slowed down with an annual increase by 4.7% on average.

**in 2006**: The total aquaculture production was reduced accidentally and the fertilizer consumption decreased by 2.22% compared with that in 2005.

**2007 to 2012** :Growth rate ranged from 0.91% to 3.92%, with average annual growth rate of 2.59%. The aquaculture fertilizer consumption estimated is 2.544 million t in 2012, accounted for 3.9% of the total fertilizer consumption (64.61 million t) in China.



## The forecasts of fertilizer consumption in aquaculture in the future



Considering the increasing restrictions to water quality and the protection to drinking-water sources as well as the decrease of fertilizer application owing to the rise of ecological fishing, the consumption of chemical fertilizers estimated in fish farming will increase by 1.5% annually from 2013 to 2023, and the consumption will reach 2.92 million tons in 2023, accounted for 4.1% of the saturation fertilizer consumption (about 70 million t).

**A conservative estimate of aquaculture fertilizer consumption in extreme case is in the level of 2.8-3.0 million t.**

## III. The use of fertilizers in fish farming in China



### The types of fertilizers :

**Nitrogen fertilizers:** including urea, anhydrous ammonia, ammonium bicarbonate (ABC), ammonium sulfate, ammonium nitrate (AN), ammonium chloride, etc.

Maximum allowable concentration :

$\text{NH}_4^+\text{-N}$ : 5 mg/L ;

$\text{NH}_3\cdot\text{H}_2\text{O-N}$ : 0.2-1.0 mg /L ;

$\text{NO}_2^-$  : 0.8mg/L

Concentration greater than the values is under anoxic conditions



### Phosphate fertilizers :

Phosphorus is an essential nutrient for algae. However, phosphorus is normally deficient in clean water

Fertilizers for common use are :

single super phosphate (SSP), triple superphosphate (TSP), ammonium phosphates (AP), calcium magnesium phosphate (CMP) etc

Maximum allowable concentration : 0.4 mg P/L



Nitrogen and phosphorus fertilizers are the major fertilizers applied in aquaculture and applied to the fish water at the ratio of 3-4:1

The balanced N/P ratio is critical to maintain the quantity of phytoplankton in the water body providing adequate food for fish

Many specialty fertilizers have been developed containing N, P and K, but also Ca, Si and micronutrients in soluble forms



The Aquaculture Specialty

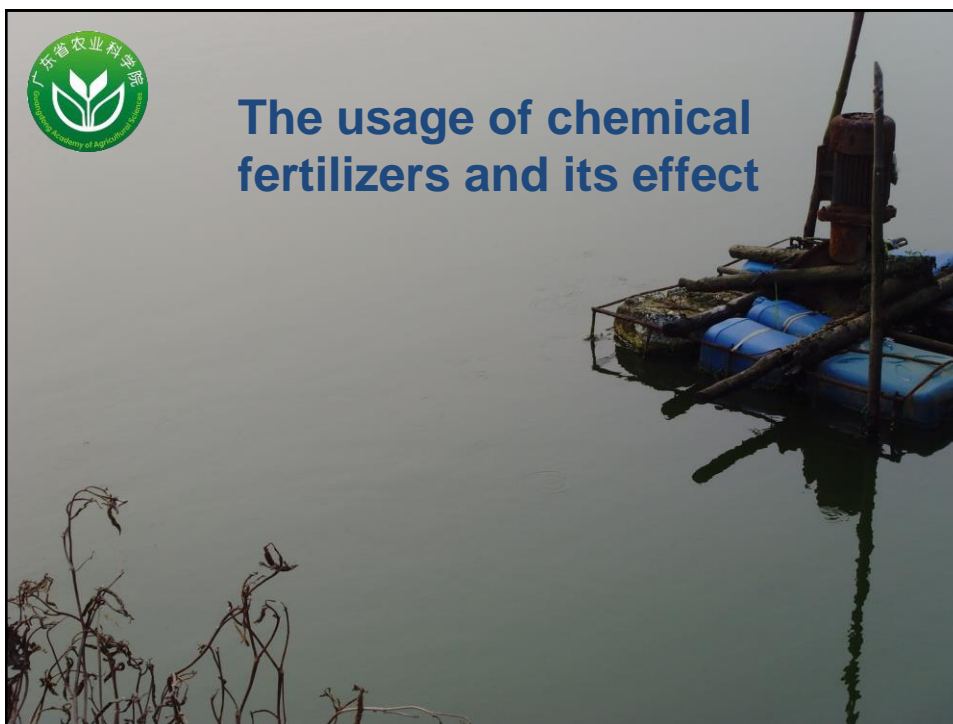
Liquid Nutrient



Other fertilizers : potassium chloride ,  
potassium sulfate , lime , powder  
limestone and silicon-containing fertilizers

Application needed when Ca below  
10mg/L and Si below 0.1-0.4ug SiO<sub>2</sub>/L





## The relevant industry standards set up and the most of them are still employed nowadays



### The standards and serial number

**Technical regulations for fish culture in ponds: Breeding technique in northeastern China**  
SC/T 1016.1—1995

**Technical regulations for fish culture in ponds: Breeding technique in Northwestern China**  
SC/T 1016.2—1995

**Technical regulations for fish culture in ponds: Breeding technique in Northwestern China**  
SC/T 1016.3—1995

**Technical regulations for fish culture in ponds: Breeding technique in Northwestern China**  
SC/T 1016.4—1995

**Technical regulations for fish culture in ponds: Breeding technique in the downer region of Chang Jiang River** SC/T 1016.5—1995

**Technical regulations for fish culture in ponds: Breeding technique in the Upper-middle region of Chang Jiang River** SC/T 1016.6—1995

**Technical regulations for fish culture in ponds Breeding technique in the delta of Pearl River** SC/T 1016.7—1995

**Specification for fish culture in paddy field** SC/T 1009 —94

**Specification for fish culture with chemical fertilizers** SC/T 1028—1999

**Technical regulations for reservoir fish farming by fertilization** SL/T177-96



## The conditions for fertilizer applications:

pH : 6.5-8.5

soluble oxygen content >5 mg/L

rainy days and/or high temperature days not suitable for fertilizer applications

## Summary of fertilizer application methods for aquaculture in China



Type of culture	Rates of fertilizer (kg/ hm <sup>2</sup> )		Application Methods
	N	P <sub>2</sub> O <sub>5</sub>	
Pond (North China)	51—169.5	16.5-57.0	Top-Dressing in Jun.-Aug. once every 5-6 days
Pond (Southwestern China)	45—142.5	30—97.5	Top-Dressing in Jun.-Aug. once every 5-10 days
Pond (Northwestern China)	75—150	45 — 90	Top-Dressing in high temp. once every 5-6 days
Pond (Middle-upper of Yangtze River)	241—379	157—247	Top-Dressing in May-Sep.. once every 5-6 days
Reservoir	300—450	105—250	once every 5-6 days in temp. 25—30°C
Lake	100—150	75—115	once (≤15kgN and 10kg P <sub>2</sub> O <sub>5</sub> ) every 10-15 days

## Manner of fertilizer application



- Fertilizers are usually dissolved in water - followed by spraying or dropping or leaking to the fish farms via boat or floatage.
- N and P fertilizers cannot be mixed together , P fertilizers are usually first applied, followed by N fertilizers.
- Use fertilizer when water temp. above 15°C
- Apply the fertilizer once in 10-15 days.

## The benefits of fertilizer use in fish farming



- **Improving water quality and increasing the types and quantity of phytoplanktons**

After using ammonium bicarbonate, N concentration reached peak level in 2-3 days for  $\text{NH}_4\text{-N}$  and in 4-5 days for  $\text{NO}_3\text{-N}$ , with quantity of planktons reaching the peak level in 5-6 days

In polyhaline water ponds 42 species of plankton were identified, after using N and P the phytoplankton biomass peaked at 288.2 mg/L. The content of chlorophyll reached peak 5-6 days after fertilization.

H.L. Wang, *et al* Effects of fertilization on phytoplankton succession in polyhaline water ponds . Journal of Fishery Sciences of China, 2005 ,12 ( 5 ) : 608—613 (in Chinese).

## Promoting fish growth



The growth of silver carp and big-head fish cultured in ponds after fertilization with ammonium chloride was promoted in body length, weight by 12.6%-15.5% and 32.5%-47.9% and the best results were received when the N : P<sub>2</sub>O<sub>5</sub> ratio was about 2:1 .

Q.S. Pan, *et al.* The growth of silver carp and bighead in polyculture ponds fertilized mainly with ammonium chloride . *Acta Hydrobiological Sinica*. 1994, 18 ( 2 ) : 116-126 (in Chinese).

## Increasing fish yield and economic returns



- 1 kg of the mixed fertilizer of urea with SSP in ratio of 1:1 applied increased fish yield by 1kg.

Data from the Research Institute of Aquatic Product

- fish yield doubled to reach 1,045 kg/ hm<sup>2</sup> when fertilizers were applied compared to those receiving no fertilizers.

S.L. Zhang, Studies on Comparison for the benefit three kinds of fish farming way in reservoir . *Reservoir Fishery*, 1995, 15 (1): 40-42 (in Chinese).

- In small-scale field, the yield with fertilization reached to 7800kg/hm<sup>2</sup> increased by about 2.5 times compared with no fertilizer treatment (2250kg/hm<sup>2</sup>). In large fields, the yield 2200kg/hm<sup>2</sup>, increased 2 times (750kg/hm<sup>2</sup>).

#### IV. Impacts of fertilizer use in fish farming on environmental quality



Proper color of water quality



The water color due to the flourish of green or red algae

#### The environmental problems received serious attention from the government and the public



- The content of phosphate and total phosphorus, the biomass of phytoplankton in the water in 1992-1993 increased by 1.4, 6.0 and 4.6 times compared to 1992-1993

Q.J. Kuang, Community dynamics of algae and limiting nutrient in Taipinghu reservoir . Journal of Lake Science, 1995, 7 (3): 235-239 (in Chinese).

In 9 reservoirs along the Yangtze River, middle to strong degree of eutrophication have been found in 6 reservoirs.

Zhu, et al Water nutritional status evaluation on 9 large reservoirs in the Yangtze River basin . Reservoir fishery, 2001, 21 (6): 30-32 (in Chinese).



**A report by the government vowed to stop the use of fertilizers in the reservoir supplying water for human consumption.**



九江责令停止使用化肥养鱼\_农业快讯\_九江农业信息网 - Microsoft Internet Explorer

地址: http://210.65.3.170/jjnyj/ReadNews.asp?NewsID=932

2006年10月9日 星期一

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发表日期: 2006年9月7日 出处: 九江日报 作者: 曹诚平 有36位读者读过此文 【字体: 大 中 小】

**九江责令停止使用化肥养鱼**  
《都昌大港水库竟用化肥养鱼》追踪

本报7月22日报道了湖北老板在都昌县大港水库用化肥养鱼,污染水质一事。5日,记者了解到,目前,有关部门已经对这种化肥养鱼行为进行了制止。

本报报道见报后,引起九江市、都昌县有关领导的高度重视,立即对此事进行了调查,证实水库水质确实严重恶化,群众的生产生活用水受到一定程度的影响。为此,水利、水产等部门根据九江市政府批示,责令水库承包人立即停止使用化肥养鱼,并办理养殖证。

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**2012**  
**中国环境状况公报**

中华人民共和国环境保护部

- In 2013, The Ministry of Environmental Protection issued a bulletin pointed out that the main pollution index in important fishing areas in 2012 were total nitrogen, total phosphorus, non-ionic ammonia, potassium permanganate index and copper. Important fishing areas in lakes including reservoirs showed relatively higher in the main pollution index in total nitrogen, total phosphorus, potassium permanganate index and petroleum, and copper, especially in the total phosphorus and total nitrogen levels.

## Fertilizer use in fish farming affects the environment in the following ways



- **N pollution:** Application of 1,500 kg/ha ABC to 2-meter deep water will generate N in the water higher than the allowable level, especially the  $\text{NH}_3$  concentration exceeding 14-120 times of the allowable level in the standard of water quality in fishery in China (0.02mg/L), causing damage to the liver and lamella of glass carp

- **P pollution:** The application of SSP at the rate of 1,500 kg/ha could increase P concentration by 35-36 times in 2-m deep water, much higher than the allowable level (0.1 mg/L). The plankton normally released back to the water about 54% of the assimilated P as soluble P.



- **Heavy Metal Pollution:** The analysis result showed that, on average, SSP contains 0.11 mg/kg Cd, 2.31 mg/kg Hg, and 8.35 mg/kg Pb. Calcium magnesium phosphate (CMP) contains 0.10 mg/kg Cd, 0.27 mg/kg Hg and 4.37 mg/kg As.

H.Y. Chen, et al Analysis and evaluation for heavy metal content of commonly used fertilizer in Guizhou province . Tillage and Cultivation, 2006 (4):18-19 (in Chinese).

## V. Prospects of the fertilizer application in aquaculture in China



- In the last 30 years, the use of fertilizers has promoted the development of aquaculture in China and became a major practice to raise fish. However, heavy and over-fertilizations have caused negative impacts on the environment and the safety of water.
- It is very important for us to develop new technology and standards regulating the use of fertilizers.
- To this end, the author tried to put forward the following outlook on China's aquaculture fertilizer use .

### ● **Strengthening of the promotion and application of the mature technology and advocating of the pollution-free cultivation.**

It is necessary to adopt the measures combining the technique extension with market access so as to promote the application of science and technology in aquaculture and the development of pollution-free cultivation.

### ● **Strengthening of the systemic research to the fertilization of fish farming.**

As the core of the protection of water ecological environment and as the goal of the production of safety fish production, more scientific fertilization technology in fish farming should be established on the basis of the comprehensive study of different fertilizers and different regions.





- **Establishing of the fertilization theory system in fish farming with Chinese characteristics.**

On the basis of absorbing the essence of the traditional fertilization technology in fish farming and combining with modern technology of chemical fertilizer application, the aquaculture scientists have responsibilities to establish the modern theory systems and techniques of the fertilization with Chinese characteristics



**Thank You !**

