Research of rural domestic sewage treatment processes in Ningbo

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Abstract. Through comparing national, provincial and municipal standards in rural domestic sewage treatment, appropriate standards and indexes are chosen to implement rural sewage treatment in Ningbo. Among some commonly used rural sewage treatment processes under such climate as Ningbo, there are four most often used processes in the first phase of Ningbo from year 2009 to 2012. In order to assess the effluent treatment effects, four typical sewage quality indexes, which are CODCr, SS, TN and BOD5, are chosen to assess effluent qualities in four typical processes. The investigation results show that every process of the four typical processes has its advantage in rural sewage treating, and there is no process can remove all the sewage pollutants to the most simultaneously. The operation results of different processes are compared in details in this paper. Through the research, it can help to eliminate inappropriate processes and explore some suitable processes for rural domestic treatment. As a result of the research of rural sewage treatment processes in Ningbo, two kinds of typical composite processes are respectively demonstrated in different occasions in water-source-protecting areas and non-water-source-protecting areas.

1. Introduction
The treatment of rural domestic sewage is different from that of urban sewage plants. Its drainage points are scattered and it is difficult to collect. Most of the rural domestic sewage should be combined in a single village or several villages in order to be treated and discharged nearby. In addition, at the beginning of Ningbo rural domestic sewage treatment in 2009, there was a lack of mature processes and corresponding emission standards with different regional characteristics. In phase 1 of Ningbo practice, in reference to urban domestic sewage treatment plants after appropriate simplifications according to local conditions, several relatively feasible processes were tried. After several years of operation, it is necessary to investigate their operation results, single out appropriate processes and eliminate inappropriate ones for practice in phase 2 of Ningbo municipal urban domestic sewage treatment.

2. Standards applicable for rural sewage effluent in Ningbo
The effluent of rural domestic sewage after treatment in Ningbo should be subject to national, Zhejiang provincial and Ningbo local standards (hereinafter referred to as "three-level standards") at all levels, and the corresponding three-level standards are compared and analyzed as followings:
2.1. National standards
At present, the applicable national standards for rural domestic sewage treatment and effluent are as followings: <Integrated wastewater discharge standard> (GB8978-1996) [1] and <Discharge standard of pollutants for municipal wastewater treatment plant> (GB18918-2002)[2].

2.1.1 <Integrated wastewater discharge standard> (GB8978-1996)(hereinafter referred to as "the national discharge standard"). At present, all sewage discharge, including rural domestic sewage, must be consistent with the national discharge standard, which was approved on October 4, 1996 and implemented on January 1, 1998. Effluent from rural sewage treatment facilities in Ningbo can be implemented as other sewage discharging units in accordance with the national discharge standard.

2.1.2 <Discharge standard of pollutants for municipal wastewater treatment plant> (GB18918-2002) (hereinafter referred to as "the national sewage plant discharge standard"). There are no relevant national standards for rural domestic sewage treatment facilities at present, so we have to implement the present guidelines by reference to the national sewage plant discharge standard, which was issued on December 24, 2002 and implemented on July 1, 2003. Related to rural sewage, level 1A or 1B and level 2 should be implemented with regarding to sewage resources or the final receiving waters to be discharged into.

2.2. Zhejiang provincial standard
Zhejiang issued provincial sewage discharge standard in 2015, which was <Discharge standard of pollutants for rural sewage treatment facilities>(DB 33/973-2015)[3](hereinafter referred to as "Zhejiang standard" or "provincial standard"). As a great convenience, it simplifies the national standards greatly to meet the needs of rural sewage treatment and discharge in Zhejiang province.

The provincial standard was released on June 29, 2015 and implemented on July 1, 2015. According to this provincial standard, considering the effluent usage or natures of the receiving waters, effluent are divided into level 1 and 2 by 7 kinds of maximum allowable emission concentration of pollutants. In important function water areas, such as water sources, lake water collecting areas, and plain river network areas with small water capacities should be implemented with level 1, other rural areas with level 2.

2.3. Ningbo local standard
There is no local rural sewage discharge standard in Ningbo till now, but some rules are enforced as a local standard in a reply released by the environmental protection bureau of Ningbo on the demand of Ningbo agricultural office (on June 23, 2009) (hereinafter referred to as "Ningbo standard" or "Local standard"). Main rules of Ningbo standard are as followings: i) In all the surface water-source-protecting zones in Ningbo, which should be category 1 or 2 of national code <Environmental quality standard for surface water> (GB 3838-88), all the surface discharge outlets are banned, both treated and untreated; ii) Land percolation or other land treatment without concentrated discharge points are permitted, but the land percolation boundary must be more than 50 meters away from water sources. Before entering the land percolation treatment system, the pre-treated sewage must meet the following requirements: COD\(_\text{Cr}\)≤100mg/L, BOD\(_5\)≤30mg/L, TSS≤30mg/L, TN≤25mg/L.

By comparing national and provincial standards with Ningbo’s, main differences lie in that no sewage outlet is allowed according to Ningbo standard in water-source-protecting areas, no matter newly constructed or original, while no new sewage outlet allowed and old ones permitted with total amount of pollutants controlled according to national discharge standard. Other items not mentioned in Ningbo standard should be subject to national and provincial standards.
2.4. Comparative analysis of effluent indexes by national, provincial and Ningbo standards

From the sensitivity of surface waters to facility effluent qualities in Ningbo, two main types of receiving water bodies can be usually divided in rural areas of Ningbo: water-source-protecting areas and non-water-source-protecting areas. Therefore, the comparative analysis should also be carried out from these two aspects. Both in water-source-protecting areas and in non-water-source-protecting areas, the strictest effluent indexes standards are chosen among the national, provincial and local standards in domestic sewage treating in Ningbo. The following comparison is based on above principles:

2.4.1 Effluent indexes in water-source-protecting areas. The request of provincial standard, in which level 1 effluent quality must be met in important water-source-protecting areas and so on, reflects the flexibility of the step-by-step implementation of rural sewage treating in water-source-protecting areas in Zhejiang, compared with other large-scale municipal sewage treatment plants.

Table 1. Comparison of national, provincial and local standards of effluent indexes of rural domestic sewage treatment facilities in water-source-protecting areas of Ningbo.

| No. | Index                | National discharge standard | National sewage plant discharge standard | Provincial standard level 1 | Local standard | The result   |
|-----|----------------------|-----------------------------|----------------------------------------|-----------------------------|---------------|--------------|
| 1   | COD$_{c}$ (mg/L)     |                             |                                        |                             |               | 60           |
| 2   | BOD$_{s}$ (mg/L)     |                             |                                        |                             |               | —            |
| 3   | SS (mg/L)            |                             |                                        |                             |               | 20           |
| 4   | NH$_{3}$-N (mg/L)    | No new sewage outlets allowed. Old ones permitted with total amount of pollutants controlled. | |                             |               | 15           |
| 5   | TP (mg/L)            |                             |                                        |                             |               | 2            |
| 6   | Fecal coliform count (CFU/L) |                             |                                        |                             |       | 10$^4$       |
| 7   | Animal and vegetable oils (mg/L) |                             |                                        |                             |               | 3            |
| 8   | pH                   |                             |                                        |                             |               | 6-9          |

2.4.2 Effluent indexes in non-water-source-protected areas. After the treatment of rural domestic sewage in Ningbo from the very beginning year of 2009 on, no effluent is permitted to be discharged directly into closed waters, such as lakes and reservoirs. After checking the relevant requirements of the three-level standards, except level 1 of Zhejiang standard for the discharge into rivers in plain areas, the effluent from non-water-source-protecting areas may be subject to level 2 standard of the corresponding three-level standards, and some relevant effluent indexes are shown in Table 2.

Table 2. Comparison of national, provincial and municipal standards on effluent indexes of rural domestic sewage treatment facilities in non-water-source-protecting areas of Ningbo.

| No. | Index                | National discharge standard level 2 | National sewage plant discharge standard level 2 | Provincial standard level 2 | Local standard | The result |
|-----|----------------------|-------------------------------------|-----------------------------------------------|----------------------------|---------------|-----------|
| 1   | COD$_{c}$ (mg/L)     | 150                                 | 100                                           | 100                        | 150           | 100       |
| 2   | BOD$_{s}$ (mg/L)     | 30                                  | 30                                            | —                          | 30            | 30        |
| 3   | SS (mg/L)            | 30                                  | 30                                            | 30                         | 30            | 30        |
| 4   | NH$_{3}$-N (mg/L)    | 25                                  | 25                                            | 25                         | 25            | 25        |
| 5   | TP (mg/L)            | 1                                   | 3                                             | 3                          | 1             | 1         |
| 6   | Fecal coliform count (CFU/L) | —                                  | $10^4$                                       | $10^4$                     | —             | $10^4$    |
| 7   | Animal and vegetable oils (mg/L) | 15                                 | 5                                             | 5                          | 15            | 5         |
| 8   | pH                   |                                     |                                                |                            |               | 6-9       |
3. Analysis of rural domestic sewage treatment results in Ningbo

According to <"Ningbo municipal rural domestic sewage planning (2009-2020)">, by 2020, Ningbo municipal rural domestic sewage collecting, treating and discharge can be divided into two phases:

Phase 1: from year 2009 to 2012. According to <"Ningbo municipal rural domestic sewage planning (2009-2020)">, the coverage rate of rural domestic sewage treated should reach more than 60%, while the population coverage rate reached more than 50%. In this phase, the key work is the collecting and treating of rural sewage, which was combined with the World Bank’s project of rural domestic sewage treating in Ningbo (2009-2016). After nearly 8 years of hard work, the implementation of 144 projects involved 336 natural villages, and benefited more than 50,000 rural homes, involving nearly 200,000 people (including migrant workers). The work of Ningbo municipal rural sewage treating was highly praised by the World Bank and was awarded "Engineering Quality" and "Effect" satisfaction medals at the end of 2016 [4].

Phase 2: from year 2013 to 2020. According to <"Ningbo municipal rural domestic sewage planning (2009-2020)">, the coverage rate of rural domestic sewage treated should reach more than 80%, while the population coverage rate reached more than 60%. In this phase, the main work is to assess the sewage processes in phase 1 through practical monitoring and to advise suitable processes in typical occasions, considering such factors as initial investment, treating effect, the convenience of maintenance and management, operating costs, year-round temperature, adaptability of water quality and quantity changes, the location in mountains or plains, terminal location in water-source or non-water-source areas and effluent quality requirements. Typical monitoring data involved in this paper were collected at this stage with thanks to Ningbo rural office providing data needed.

From 2009 to 2012 in the first phase of rural sewage treating in Ningbo, in addition to discharge into municipal sewage networks, rural sewage treating processes mainly included the following four kinds: (1) A/O integrated process; (2) Rotating biological contactor process; (3) Combined process of anaerobic and land percolation (or constructed wetland) treating (hereinafter referred to as "Anaerobic + land process"); (4) Bio-trickling filter process. The above four processes were mainly applied in the first phase of rural sewage treating in Ningbo, so they are called “Four commonly-used processes”. Their proportion statistics in phase 1 through investigation are shown in figure 1:

![Diagram showing the proportion of the four commonly-used processes in phase 1 of Ningbo rural sewage treating processes. A/O integrated: 21.66%, Bio-trickling filter: 53.50%, Anaerobic + land: 21.66%, Rotating biological contactor: 3.18%]

Other scattered treatment methods were not included in the above statistics, such as septic tank + small constructed wetland + land percolation for some scattered homes far away from villages. In addition, villages close to the municipal pipe network should try their best to be included in the
municipal pipe network and be delivered to municipal sewage treatment plants, whose processes are not included in above statistics.

In particular, COD means COD\textsubscript{Cr} when COD mentioned later without being specifically pointed out.

3.1. The investigation of Ningbo rural sewage treatment facilities in phase 1

3.1.1. The monitoring and analysis of inflows and effluents water indexes in the four commonly-used processes of Ningbo rural sewage treatment facilities in phase 1.

In view of small-scale of rural domestic sewage and its a long distance away from the laboratories, the water quality monitoring indexes are appropriately simplified into four groups of key indexes: COD\textsubscript{Cr}, SS, TN and BOD\textsubscript{5} (hereinafter referred to as "four key water quality indexes").

Judging from a single index, A/O integrated process made a good achievement in removing COD\textsubscript{Cr}, BOD\textsubscript{5} and SS, while anaerobic and land composite process was good at removing TN. At the same time, there was no process among the four commonly-used processes, who can succeed in removing all the pollutants at the most simultaneously.

Judging from the comprehensive effect of four key water quality indexes, the removal rate of A/O integrated process is much more higher and stable, while the removal rate of rotating biological contactor process is the most poor and unstable. Meanwhile, bio-trickling filter process, anaerobic and land composite process stood between A/O integrated process and rotating biological contactor process. Detailed monitored results are shown in Figure 2.

![Figure 2. The average removal rates of COD\textsubscript{Cr}, SS, TN and BOD\textsubscript{5} in the four commonly-used processes of rural sewage treatment facilities in phase 1 of Ningbo.](image)

3.1.2. Qualified rates of the effluent from the four commonly-used processes of Ningbo rural sewage treatment facilities (according to level 1 of provincial standard).

Through investigations rural sewage treatment facilities in phase 1 of Ningbo, effluent qualification rates varied a lot along with different processes as shown in Table 3:
Table 3. Average qualified rates of different indexes in Ningbo rural sewage treatment facilities in phase 1.

| Process                     | COD   | SS    | TN    | BOD₅  |
|-----------------------------|-------|-------|-------|-------|
| A/O integrated             | 94.29%| 83.87%| 8.57% | 66.10%|
| Bio-trickling filter        | 83.78%| 72.06%| 13.70%| 42.25%|
| Anaerobic + land            | 64.52%| 70.97%| 16.13%| 31.03%|
| Rotating biological contactor| 40.00%| 40.00%| 0.00% | 0.00% |

In Table 3, BOD₅ was transferred to level 1B of the national sewage plant discharge standard because Zhejiang standard does not include this index. It can be seen that qualified rate of TN is the lowest and qualified rate of COD is the highest in Table 3 among the four key water quality indexes in treatment of rural sewage in Ningbo. According to four key water quality indexes of effluent, A/O integrated process is more suitable for Ningbo rural sewage treating, although it didn’t do very well in removing TN in phase 1 of Ningbo.

For a single process, when ranked by the items of the highest qualified rate of the four key water quality indexes, the highest qualified rate lies in A/O integration process, which achieved 3 items among 4, while Anaerobic and land composite process with 1 item among 4 respectively. Meanwhile, both bio-trickle process and rotating biological contactor process won 0 item among 4.

In terms of the qualified rate through Table 3, A/O process and land treatment process are more suitable in the next phase to treat rural sewage in Ningbo, so as to achieve the maximum qualified rate of four key water quality indexes. It can also be suggested that bio-trickling filter and rotating biological contactor process would better to be eliminated gradually in the next phase of rural domestic sewage treating in Ningbo.

Through random sampling, the living environment in Ningbo rural areas has been greatly improved in all the villages where domestic sewage has been collected and treated, and the well-being of the villagers has been greatly improved, with nearly 100% satisfaction with this work, even if in villages where the quality of treated effluent has not reached the three-level standards.

3.2. The investigation of part of the Ningbo rural sewage treatment facilities in phase 2 (2013-2017).

From 2013 to 2017, 40 rural sewage treatment processes in phase 2 were investigated in Ningbo. The sewage treatment processes are shown in figure 3.

![Figure 3. Map of 40 rural domestic sewage treatment processes in Ningbo during phase 2 through the survey from 2013 to 2017.](image)
It shows that, on the basis of previous operation and monitoring, the following trends have become clear in phase 2:

- **Biofilm processes have been reduced gradually in the choice of rural sewage treatment process in Ningbo.** Biofilm processes with poor BOD and COD removal effect in phase 1 of Ningbo have not been applied in phase 2, including both rotating biological contactor process and bio-trickling filter process.
- **Integration of A/O process and its composite processes are still widely applied in engineering of phase 2 in Ningbo rural sewage treating, accounting for 15% and 40% respectively, and the total amount is up to 55%.** It shows that A/O process and its composite processes occupy an absolute dominant position, and the monitoring result of good BOD$_5$ and COD removal rate in phase 1 may explain the reason.
- **Land treatment technology and its composite with other processes technology are accounted for from 21.66% in phase 1 to 65% in phase 2, among them, anaerobic and land composite treatment from 21.66% in phase 1 to 25% in phase 2, A/O and land composite treatment from 0% in phase 1 to 40% in phase 2.** It is based on anaerobic and A/O process’s good effect on BOD, COD, TN removal rates in phase 1, while land treatment processes being good at TN removing.
- **Composite processes have gradually come into majority, accounting for 65% in phase 2, up from 21.66% in phase 1.** And some kinds of land treatment processes are used in every composite process as a terminal process in phase 2. Based on strong advantages of land treatment in removing TN, which is a key pollutant in rural sewage treatment, effluent quality from composite processes is more stable.
- **New processes have been applied in some projects in cautious exploration, such as MBR integration process, but the proportion is relatively small, which accounts for only 2.5%.**
- **Sewage discharged into municipal pipeline networks has been increased quickly, accounting for 17.5% in phase 2.** It shows that the coverage of municipal sewage pipeline networks expanded year by year has created favorable opportunities for accepting more sewage from villages nearby.

### 4. Choice and design of processes for rural domestic sewage

In choosing the treatment process of rural domestic sewage in Ningbo, final receptors of sewage should be paid attention to for the first, such as, whether or not being in water-source-protecting sites, or there being a receiving municipal pipeline network. It is forbidden to construct sewage outlets in water-source-protecting sites in Ningbo. For the second, it should be focused on the investigation of whether or not there being a network to collect sewage or there being a convenience to construct a terminal sewage treating plant in villages far away from municipal pipeline networks.

If a terminal sewage treating plant has to be constructed, there are two kinds of treating systems, which are joint household individual dispersion treatment system and centralized sewage treatment system. Centralized treating system is chosen for priority rather than a individual treating one, because individual treating systems are more difficult to maintain in remote villages. The conventional method mostly only includes FRP septic tank and constructed wetland with fluctuant effect. At the same time, the treatment processes of discharging into municipal pipe networks are not discussed here. The following analysis is focused on the centralized treatment terminal process for rural sewage.

In the choice of centralized treatment technology for rural domestic sewage without civil sewage pipes access conditions, we should first pay attention to whether or not it is located in a water-source or non-water-source area. The following cases are two typical examples of rural domestic sewage treatment processes in non-water-source-protecting area (case 1) and water-source-protecting area (case 2) in Ningbo.

#### 4.1. Case 1: typical process of rural domestic sewage treatment in non-water-source-protecting area

**Overview of case 1:** The village is located in a plain area of rural Ningbo, with 580 permanent residents (migrant workers included), without any farmhouse restaurant, in a
non-water-source-protecting area. There is a river downstream of the village, and its water capacity is large, whose water is defined as surface water category IV according to national code GB3838-2002.

In non-water-source-protecting areas, the requirements for effluent quality are relatively low, so A/O and constructed wetland composite processes are often adopted.

4.1.1. The quality indexes and quantity of inlet water in case 1
a) The quality indexes of inlet water in case 1
With reference to the pre-evaluation memorandum of World Bank delegation during the implementation of rural sewage treatment in Ningbo (May 4-15, 2009), the inlet water quality of typical rural designed sewage in Ningbo can be advised as shown in Table 4:

Table 4. Inlet water quality indexes values.

| Inlet water quality indexes | COD (mg/L) | BOD₅ (mg/L) | TSS (mg/L) | NH₃-N (mg/L) | TP (mg/L) |
|----------------------------|------------|-------------|------------|--------------|-----------|
| Values                     | 250-300    | 120-150     | 150        | 25-30        | 5         |

b) Quantity of inlet water in case 1
The calculation of sewage quantity can be obtained by multiplying the water consumption by the coefficient of sewage. The total amount of comprehensive water consumption is obtained according to the index of daily comprehensive domestic water consumption and population planning. The coefficient of sewage includes sewage production rate, interception rate and daily variation coefficient.

According to a survey, average daily water consumption per capita is 80L/p·d.

Therefore, the daily water treatment per capita is:

\[80 \times 0.85 \times 0.9 \times 1.3 = 79.56 \text{L/p·d} \quad \text{(Take integer as 80L/p·d)}\]

Among them: 80 —— average daily water consumption per capita, L/p·d;

0.85 —— sewage discharge coefficient;

0.9 —— sewage interception rate;

1.3 —— sewage daily variation coefficient;

There are about 580 persons in the village where the case is located, including migrant workers. So the daily sewage can be calculated as following:

\[80 \times 580 = 46400 \text{L/d} = 46.4 \text{m}^3/\text{d}\]

Considering 5% margin of sewage treatment facilities, the daily sewage treating capacity of the terminal can be designed as following:

\[46.4 \text{m}^3/\text{d} \times 1.05 = 48.7 \text{m}^3/\text{d}\]

So the sewage treatment daily capacity can be taken integer as 50m³/d.

4.1.2. Final destination of the effluent and main indexes of effluent in case 1
a) Final destination of the effluent
According to conditions set in case 1, the treated sewage will be discharged into a river near a non-water-source area, which belongs to surface functional water of category IV according to National code GB 3838-2002.

b) Main indexes of effluent
According to National discharge standard, level 2 standard should be implemented for discharge into category IV waters.

According to National sewage plant discharge standard, it is accordant with level 2 standard for discharging into surface category IV functional waters.

According to Zhejiang standard, new facilities in areas with important water environment functions, such as water sources, collecting areas of lakes and reservoirs, and in areas with small water environment capacity, such as plain river network, shall be subject to level 1 standard. Level 2 standard in other regions. Although the case is located in a plain area, it has a large water environment capacity and level 2 standard can be implemented according to Zhejiang standard.

According to the requirements of Ningbo standard, effluent discharged into surface function water of category IV and V of National code GB3838-2002, or sea water of category III of National code
GB3097-1997 should be implemented as level 2 of national discharge standard. So, level 2 of national discharge standard should be applied in this case according to Ningbo standard. By comparing the above four aspects and considering the three-level standard’s time sequences and operability, the designed effluent quality shall be implemented as level 2 of Zhejiang standard.

4.1.3. Treatment process in case 1

4.2. Case 1: Typical process of rural domestic sewage treatment in water-source-protecting area.

The population and designed inlet water quantity in case 2 are the same as in case 1, except that the village is located in a water-source-protecting area. According to Ningbo standard, in a water-source-protecting area, both treated and untreated surface discharge points are all banned, and processes with landpercolation or other land treatment processes of no concentration surface discharge point is allowed. It should be mentioned that aland percolation’s boundary must be more than 50 meters away from any receiving water.

In above section, it is mentioned that the treatment process in non-water-source-protecting area can be suggested to adopt A/O pond and constructed wetland composite process. On this basis, such deep treatment units as ecological pond or land percolation processes are added to meet the requirements of no surface sewage discharge point.

4.2.1. Quality indexes and quantity of inlet water in case 2. Quality indexes and quantity of inlet water in case 2 are the same as in case 1.

4.2.2. Final destination of effluent and main indexes of effluent in case 2. No surface sewage discharge point can be allowed to construct in water-source-protecting areas in this case. Meanwhile, inlet water quality before entering land percolation should meet the requirements of the followings according to Ningbo standard: COD$_{cr}$ ≤100mg/L, BOD$_5$ ≤30mg/L, TSS ≤30mg/L and TN≤25mg/L.
4.2.3. Treatment process in case 2

Figure 5. An example of A/O, constructed wetland, aquatic plant pond and land percolation composite process.

5. Conclusion
Along with the advances of Ningbo rural domestic sewage treatment, some processes with stable effluent qualities and reliable operation have become dominated, such as the integration of A/O process, A/O process combined with land treatment, anaerobic process combined with constructed wetland, which may be used as references for regions with similar climates of hot-summer and cold-winter.

Practice in Ningbo also shows that investigation and analysis of exiting rural domestic sewage treatment facilities can promote the operation management and give hints to the subsequent construction of rural domestic sewage. It can also help to eliminate processes whose effluent qualities are not stable or not up to correspondent standards, can explore some more suitable processes for rural domestic treatment.

Therefore, it can seen that the cycle of design, construction, operation, investigation, analysis and design improvement. The exploration and improvement of Ningbo rural domestic sewage treatment will never stop, and it can be expected that better treatment effluent water qualities would be achieved, promoting regional surface water environment continuously at the same time.

References
[1] National environmental protection bureau, state bureau of technical supervision.(1996) integrated wastewater discharge standard (GB8978-1996), Beijing.
[2] National environmental protection bureau, state bureau of technical supervision.(2002) Discharge standard of pollutants for municipal wastewater treatment plant (GB18918-2002), Beijing.
[3] Zhejiang provincial government.(2015) discharge standard of pollutants for rural sewage treatment facilities(DB 33/973-2015),Hangzhou.
[4] Ningbo Daily.(2016) Ningbo municipal rural sewage treatment has entered sprint stages. http://www.h2o-china.com/news/249171.html.