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suggestions to Felindre water treatment plant

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Abstract

Through on-the-spot investigation of Felindre water treatment plant, the knowledge of basic water treatment process is mastered. The water is usually treated by these steps: coagulation, flocculation, precipitation, filtration and disinfection. Based on the information about Felindre water treatment plant, the following tasks were done: drawing the basic layout of water plant; stating the overall operation of the plant; explaining the detailed principle and the capacity of each processing unit. The treatment process in Felindre water treatment plant uses coagulation, COCODAFF, GAC, rapid gravity filtration and disinfection. COCODAFF and GAC are added to the ordinary water treatment plants. COCODAFF is an advanced process combining flotation and filtration; GAC is physical adsorption of water. All of them improve the quality of effluent. By analyzing and thinking about the water quality problems in the plant, feasible solutions that are benefit to water supply and sanitation can be put forward: Lime and Soda ash can be added for hardness problems; Zeolite and chitosan can be used to adsorb toxic heavy metals and non-degradable substances. In addition, considering the limitations of rapid gravity filtration in the original process, the reverse osmosis membrane filtration method is suggested to replace the gravity filtration method. Finally, combining all the above suggestions, a modified layout can be obtained.

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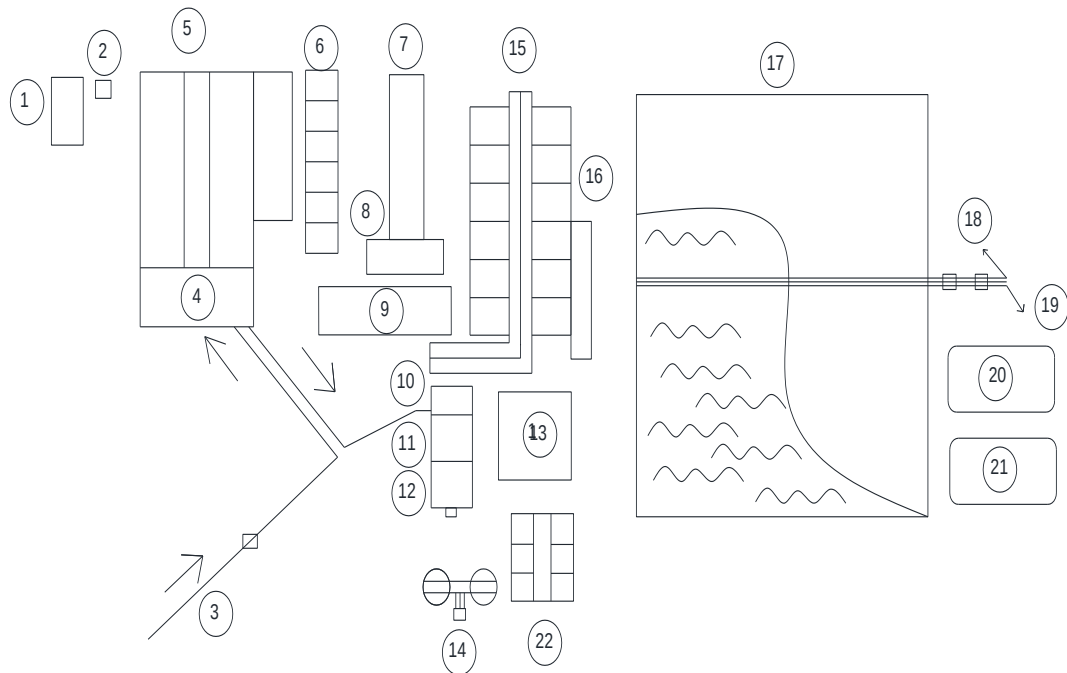
1 Introduction

With the help of the water plant information obtained from the Felindre water treatment plant, combined with the task requirements, first of all, a general introduction of the water plant need to be illustrated, including the overall layout, operation mode, as well as the principle and capacity of the processing unit. Then appropriate solutions are needed to solve the problems raised in the assignment about the hardness and toxic heavy metals caused by the deterioration of water quality. Overall analysis of water plant process is indispensable which can be targeted to put forward suggestions for optimization and improvement. Finally, the layout of the improved water plant should be drawn according to the requirements of all aspects.

In the treatment process of Felindre water plant, the principle、advantages and disadvantages of each process need to be very clear, so that the improvement suggestions can be put forward according to its disadvantages. When analyzing solutions to hardness and toxic heavy metals, the economic benefits of the plant and the coordination degree of the overall operation should also be taken into account to make things better. According to the above ideas to solve practical problems, a more appropriate solution can be obtained. By using environmental science and engineering knowledge, a reliable, affordable and sustainable water supply service can be achieved.

2 General description of Felindre water treatment plant

2.1 The layout of the whole treatment plant



1.WASH WATER TANK 2.SERVICE WATER TANK 3.RAW WATER IN FROM LLIW RESERVOIRS 4.CONTACT TANKS 5.COCODAFF PLANT 6.COAGULANT PUMP HOUSE 7.CHEMICAL STORE 8.LIME SILOS 9.CONTROL HOUSE 10.MANGANESE REMOVAL STORE 11.SUPERNATENTS BALANCING TANK 12.WASTE BALANCING TANKS 13.COVERED FILTERED WATER CONTACT TANK 14. SLUDGE THICKENING PLANT 15. GRAVITY FILTERS 16.FILTERED WATER CONTACT TANK EXTENSION 17.TREATED WATER SERVICE RESERVOIR 18.WATER TO EAST 19.WATER TO KIDWELLY 20.SLUDGE LAGOON NO.1 21.SLUDGE LAGOON NO.2 22.WASH WATER RECOVERY TANKS

Figure 1 the general layout of the whole Felindre water treatment plant

2.2 The basic principles of operations in water treatment plant

Dwr Cymru Welsh Water which supplies most of Wales and some bordering areas of England with water and sewage services, providing customers with clean, safe drinking water and taking away sewage 24 hours a day , 365 days a year.

With an average of 420 litres of water per household per day, The maximum household water is a toilet,

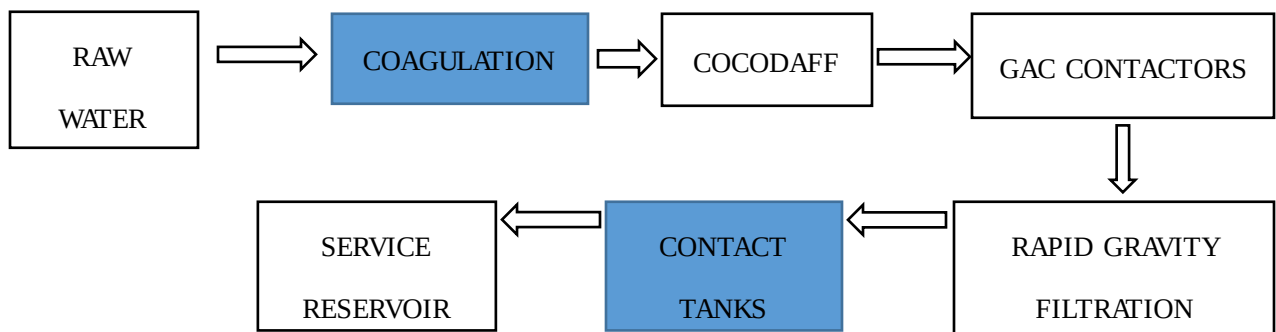
followed by a bathtub, a shower and a washing machine. In order to make sure everyone has enough water, we have established a network of reservoirs in the whole region to collect the water we need.

In general, the raw water in rivers and reservoirs is very clean, but we also have the responsibility to dispose it and ensure the water is safe to drink. We have a network of water treatment works such as Felindre for this job. Some treatment plants like Felindre take charge of such work. The general treatment principles in Felindre are as follows:

Water flows 65 kms down the river Tywi from Llyn Brianne to Nantgaredig and is then pumped 26kms to the Lower Lliw reservoir. The reservoir has a capacity of 1221 million liters. Together with the nearby upper Lliw reservoir, it provided at least seven days of supply to prevent possible disruptions to the main pollution of the River Towy from Llyn Brianne.

Felindre handles an average of 227,000 cubic meters of water per day. Parts are buried underground or covered. The dimensions of some equipment and devices are not obvious.

The general Process flow diagram is as follows:



White represents physical processes and blue represents chemical processes

The raw water is first sampled to test its conductivity, turbidity, pH and temperature. Secondly, the raw water is added the coagulant and electrolyte to complete the coagulation process, and then it flows to COCODAFF plant. This is Counter Current Dissolved Air Flotation and Filtration. The solids are removed using this process by lifting with air saturated water. After the process of flotation and filtration, the sludge forms a floating layer at the top, and the filtered clean water is collected at the bottom. Before entering GAC CONTACTORS, the water sample is tested a second time for turbidity, aluminum content and particle count. After coming out from COCODAFF, water is sent to GAC plant. The full name of

GAC is Granular activated carbon and the principle is to use the adsorption of activated carbon to adsorb the impurities from the treatment water to the surface, and continuously remove the impurities in the water, so as to achieve the purification of water. The water from the GAC needs to be measured for phosphoric acid and chlorine concentrations, as well as turbidity and pH. After the adsorption and impurity removal process, it enters the RAPID GRAVITY FILTRATION for secondary filtration and removal of manganese. The clear filtered water collected at the bottom and the filters are regularly cleaned and the sludge removed for disposal. The water enters the CONTACT TANKS where disinfection occurs by addition of chlorine and pH adjusted of lime. The treated water from the contact tanks need to detect residual chlorine and turbidity. When the water quality is standard, the water enters the SERVICE RESERVOIR and water distribution system. The water needs to be checked again before being sent to the users (Felindre, 2018).

3 The technology available for the treatment of each site

3.1 Coagulation and COCODAFF

There are two RAW WATER FLASH MIXERS, each 5.8m square by 6.7m deep. And three RAW WATER CONTACT TANKS, each of which has a capacity of 530 cubic meters. Adding coagulants with positive ions into the raw water, a large number of positive ions exist between colloidal particles to eliminate the electrostatic repulsion between colloidal particles, so as to make the particles coalesce. This method of adding positive ion electrolyte makes the colloidal particles coalesce with each other, which is called coagulation. The chemical added to water to destabilize colloids are called coagulants. The most common inorganic coagulants used water treatment are Aluminum sulfate and Iron salts and organic coagulants are polyelectrolytes like Nonionic, Anionic, Cationic and so on. The coagulants in Felindre is Alumina and polyelectrolyte. There are various forms and several functions of polyelectrolyte in water treatment. It normally takes the responsibility to regulate filter water in Felindre. The average capacity is 227000 cu.m/day and the peak capacity is 273000 cu.m/day.

Generally, coagulation does not exist alone in the process of water treatment. There will be flocculation and sedimentation process after coagulation process. After coagulation, there will form a polymer in raw water. This kind of polymer can act as a bond bridge between two particles far away from each other, making the particles gradually become larger and eventually form a flocculation of large particles, accelerating particle deposition. Sedimentation is a process in which precipitates and trapped impurities settle to bottom. Most impurities can be removed by all the three process (Anu Matilation, 2010).

The full name of COCODAFF is counter current dissolved air flotation and it is a combination of flotation and filtration. Flotation and filtration take place in the same tank in a counter current flow. Flotation takes place in the top of the tank and filtration in the bottom. The coagulated water first mixes with the pressurized dissolved gas water, and the flocs formed is in full contact with the micro bubbles and enter the separation chamber of the gas floating chamber. The flocs with specific gravity which are less than the water are floating on the upper layer to form a sludge layer in the top of the tank. Those that are heavier than water enter into the filtering section with the water body, so that impurities are removed by filtering materials, and the cleaned water source can be obtained (Shen Zhang, 2019).

The principle of flotation is to make air dissolved in water under pressurized conditions, and then the dissolved air release system depresses the pressure instantaneously. The sudden release creates a large amount of micro bubbles, allowing the flocs and some tiny particles to bind to the micro bubbles (Wang LK, 2005). Filtration is the removal of suspended impurities in water through particle filter materials, using mechanical filtration, precipitation and contact flocculation. Meanwhile, it can also remove COD, Cr, BOD₅, heavy metals, bacteria, viruses and other substances. Filter materials are usually anthracite, fine sand, medium, coarse gravel and so on (Baidubaike, 2018).

What calls for special attention is that the inlet coagulated raw water and air saturated recycle water flow counter current too each other. The dissolving air water release nozzles are located below the flocculated water and above the filter material. Therefore, the bubbles are evenly distributed in the tank, which avoiding turbulence of the air bubbles in the contact area and damage to the floc caused by the turbulence. The scum layer is supported by deep bubbles, and the dislocated flocs reattach to the bubbles so that a good separation effect is achieved. It is a new type of water purification process which combines flotation and filtration with high practicability. The process has the advantages of compact structure, simple operation and small occupation area. It is suitable for the reconstruction of new small water plants and old water plants and has good promotion value. The medium of filtration is anthracite and sand beds.

There is also a backwash process in COCODAFF plant. Backwash, also known as filter washing, aims to remove impurities trapped in the filter material layer and restore the filter capacity in a short time (Baidubaike, 2018). In the backwash operation, the water flows back through the filter through the bottom drainage system to flush out the blockage in the filter material and reduce the factor of water head loss. Finally, it is discharged from the middle pipe of the pool. Different types of filter have different recoil strength and recoil time. The backwash interval is 36 hours and the backwash flow is 225L/s.

3.2 GAC contactors

GAC which is the abbreviation of granular activated carbon is a kind of adsorption. Adsorption is a nature process by which molecules of a dissolved substance collect on and adhere to the surface of an adsorbent. Adsorbent is the solid material onto which the adsorbate accumulates. Adsorbate is the

dissolved substance that is being removed from liquid phase to the solid surface of the adsorbent. The application of adsorption in water treatment is mainly to remove dissolved organic matter, such as some synthetic organic matter, organic by-products and some smell and color problems caused by organic chemicals. There are three main types of adsorbents: activated carbon, silicon, synthetic polymer, activated carbon is widely used in water treatment plants.

Activated carbon is a kind of microcrystalline carbon with black appearance, developed internal pores, large specific surface area and strong adsorption capacity. In addition to carbon, it contains oxygen, nitrogen, hydrogen and ash. Due to the removal of volatile organic compounds in the manufacturing process, a gap is formed between the lattice, forming many small pores of different shapes and sizes, so that the activated carbon has a huge specific surface area, and has a strong adsorption capacity for organic compounds dissolved in water, which has a good treatment effect when used in water treatment plants. When the flow rate is low, the filtration capacity of the unit mainly comes from the screening effect of activated carbon, while when the flow rate is fast, the filtration capacity comes from the adsorption of activated carbon particles on the surface. In the process of filtration, the larger the surface area of particles provided by activated carbon, the stronger the adhesion to suspended matter in the water (Yang Zhang, 2008).

According to the appearance, activated carbon has two types :powder activated carbon and granular activated carbon. Powder activated carbon has strong adsorption capacity, simple preparation, low price, but difficult regeneration, generally cannot be reused. Granular activated carbon is more expensive, but renewable reuse, and easy to operate which is widely used. With the development of the fiber industry, the birth of a new type of activated carbon adsorption material - activated carbon fiber, it is the third generation of products after granular, powdered activated carbon (Baidubaike, 2019).

The adsorption capacity of granular activated carbon is mainly affected by three factors: 1, the nature of the adsorbent: the adsorbent that has large surface area will have strong capacity of adsorption; activated carbon is a non-polar molecule, easy to adsorb non-polar or very low polarity adsorbent; activated carbon adsorbent particle size, pore structure and distribution and surface chemical properties have a great impact on the adsorption. 2, the nature of adsorbate: depends on its solubility, polarity,

concentration and so on. 3. Solution pH: since activated carbon can absorb hydrogen and oxygen ions in water, it affects the adsorption of other ions. The adsorption effect decreases with the increase of the pH value of the solution. When the pH value is higher than 9.0, it is not easy to adsorb. The lower the pH value, the better the effect. The optimum pH range should be determined by experiment in practical application (Douding, 2016).

Although activated carbon has a strong ability to absorb dissolved organic matter in water treatment, it will reach the maximum capacity of absorption after a certain degree of treatment. At this state, activated carbon is called as spent activated carbon. In order to recycle activated carbon, we need to carry out the process of regeneration. Activated carbon regeneration is defined as the removal of adsorbents adsorbed on activated carbon by physical or chemical methods without damaging the original structure of activated carbon, so as to restore its adsorption properties and achieve the purpose of reuse. The methods of regeneration include heating regeneration, biological regeneration, wet oxidation, solvent regeneration and so on (Baidubaike, 2017). After regeneration, the spent carbon is reactivated by the same way by which the original carbonaceous was activated. Some of the adsorptive capacity (2%-5%) of the AC is lost permanently during regeneration. Some carbon (4%-8%) is lost due to mishandling. So a makeup amount of carbon should be added to the system. GAC also needs the backwash process which is similar with the backwash in COCODAFF, but the interval is 4 days.

3.3 Rapid gravity filtration

Filtration is the operation of separating solids and other substances from liquids (or gases) in suspension under the action of driving force or other external forces through the medium in which solid particles and other substances are trapped by the filtration medium. Water treatment filters use sand, crushed anthracite coal, and granet on a graded gravel base. For the filtration process to occur, two things must happen: 1, there are a collision between particle and filter medium. 2, the particle must be deposited onto the filter medium. The filtration is made up of two parts: transport and attachment. According to flow through medium, the filtration can be divided into two types: gravity filters and pressure filters. Gravity filters are open to the atmosphere and flow through the medium is achieved by gravity. Gravity filtration is classified into rapid filtration and slow filtration. The medium of pressure filters is contained in pressure vessel and water is delivered to the vessel under pressure.

The rapid gravity filtration is used in Felindre secondary filtration. The mediums are anthracite, fine sand, medium and coarse gravel. As the water passes through the filters, flocs produced in the raw water contact tanks are retained and the clear filtered water collected at the bottom. The filters are regularly cleaned and the sludge removed for disposal. There are twelve rapid gravity filtrations and are each capable of processing up to 25 million liters a day peak demand.

3.4 Contact tanks

A contact tank is a tank used in water treatment to facilitate contact between chemicals or other substances and the treated liquid. In Felindre, contact tanks are used for disinfection and adjustment of pH. The water flows into the contact tanks where chlorine is added to destroy all harmful bacteria and pH is adjusted by addition of lime. The filtered water contact tank is an underground reinforced concrete tank 24 meters square by 5.8 meters deep with a capacity of 2.7 million liters. Before the water comes out of the contact tank and enters the reservoir, the turbidity, residual chlorine, conductivity, manganese and aluminum concentrations of the water samples need to be tested again to determine whether they meet the effluent water quality standards. If the concentration of chlorine exceeds the limit, sulfur dioxide is used for dechlorination.

3.5 Treated water service reservoir

The reservoir is used to store the clean water processed by the whole treatment system, and then sent to the distribution system for users to use. Color, odor, free chlorine, turbidity, conductivity and pH should be measured before delivery to the distribution system to ensure that they meet the standards before delivery to various places for use. The massive service reservoir which is 160 m square and 7.5m deep has a capacity of 150 million liters.

3.6 Other affiliated plants

Wash water recovery plant is the gathering point of backwash water. Wash water recovery plant which is away from the main treatment process is made up of 6 hopper bottom tanks. Each 10 meters square with an overall depth of 10 meters, Giving a working capacity of 500 cubic meters. Polyelectrolyte also plays an important part in here. As wash water enters the plant, the action of Polyelectrolyte is to cause the solid particles to stick together. Thus forming a thick sludge which drops to the bottom of the tanks and ensures that the water in the top of the tank is clean and suitable for recycling to the works inlet.

The sludge thickening plants are two circular concrete tanks each 9 meters in diameter with a capacity of 140 cubic meters.

All the chemical used in the treatment process are batched or make up in the treatment and control house which also acts as workshops and base for staff.

4 Process optimization suggestions and considerations

4.1 Hardness

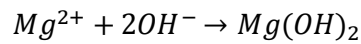
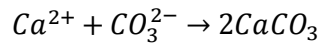
Water hardness is a property that indicates water resistance to soap bubbles produced by soap. Hardness salts generally include Ca^{2+} , Mg^{2+} , Fe^{2+} , Mn^{2+} , Sr^{2+} , Te^{3+} , Al^{3+} and other metal cations that are easy to form insoluble salts. In general natural water, Ca^{2+} and Mg^{2+} are the main ones, with less content of other ions. Therefore, the total amount of Ca^{2+} and Mg^{2+} in water is often used as the definition of hardness.

Considering the composition of anions in water, hardness can be divided into carbonate hardness and non-carbonate hardness. Carbonate hardness is mainly composed of calcium and magnesium bicarbonate [$\text{Ca}(\text{HCO}_3)_2$, $\text{Mg}(\text{HCO}_3)_2$], and a small amount of carbonate hardness. The hardness of bicarbonate is also called temporary hardness because it is decomposed into precipitates after heating and removed from water. Non-carbonate hardness is mainly formed by the sulfate of calcium and magnesium, chloride and nitrate and other salts. Such hardness cannot be removed by means of thermal decomposition, so it is also called permanent hardness, such as CaSO_4 , MgSO_4 and so on. The unit of Hardness is per litre of water: mg/L as calcium carbonate (CaCO_3) (Baidubaike, 2018).

When water passes through or over mineral deposits such as limestone, the concentration of Ca^{2+} , Mg^{2+} and HCO_3^- ions increase causing the water to be classified as hard water. Calcium carbonate concentration in water below 60mg/L, is considered soft water; between 60 and 120 mg/L, is considered moderately hard; between 120 and 180 mg/L, is considered hard; more than 180 mg/L, is considered very hard (W, 2000).

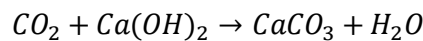
Removing hardness causing ions like Ca^{2+} , Mg^{2+} from water by using chemical methods is defined as softening. In general, there are two methods to soften water: 1, Ion exchange. Although zeolite and ion exchanger are insoluble in water, sodium ions and hydrogen ions in them can exchange with calcium and magnesium ions in hard water, so that calcium and magnesium ions can be removed by adsorption of zeolite, and ion exchanger. Zeolites and ion exchangers that fail after long-term use can be reused through regeneration, so this method is both economical and advanced soft water method. 2, Using the Lime-Soda Ash method. In the chemical precipitation method the objective is to produce CaCO_3 , Mg

(OH)₂ (Wu, 2018).

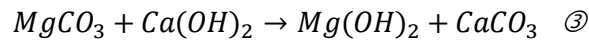
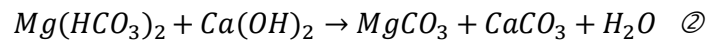
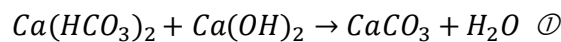


When adding Lime (Ca(OH)₂), and Soda ash (Na₂CO₃) into water, these two reactions will occur. To precipitate CaCO₃, Mg(OH)₂, we need to raise the pH to 10.3 by adding Lime. The addition of the OH⁻ will transform all the HCO₃⁻ to CO₃²⁻. We also need to raise the pH to 10.8 by the addition of Soda ash. This will add the CO₃²⁻ ion needed to react with the remaining Ca²⁺. Lime is responsible for removing chemicals which cause carbonate hardness. Soda ash is responsible for removing chemicals which cause non-carbonate hardness. Calcium hardness will be reduced by the formation of calcium carbonate from calcium ions, and magnesium hardness will be reduced by the formation of magnesium hydroxide from magnesium ions. Here are some examples of equations.

Neutralization of carbonic acid :

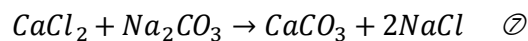
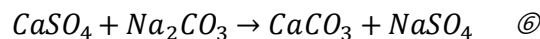
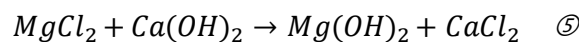
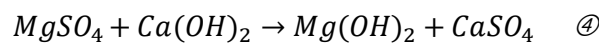


Removing CH causing by calcium and magnesium:



In equation ②, magnesium carbonate is soluble., so it needs more lime to precipitate.

Removing NCH causing by calcium and magnesium:



Softening does not completely remove the hardness of the water because there is always a small residual amount of calcium carbonate and magnesium hydroxide in the water. Generally in terms of calcium carbonate, the minimum hardness of water is 40mg/L (including calcium and magnesium ions). Normally the hardness of treated water is 75-120 mg/L as CaCO₃. Removal of magnesium ions requires excess lime. With calcium carbonate as the stoichiometry, the minimum excess amount of lime is 20mg/L and the maximum excess amount is 62.5mg/L. Magnesium ion in excess of 40mg/L as calcium

carbonate is not desired as it forms scale in water heaters. Scale will be formed in water when the content of magnesium ions exceeds 40mg/L, and the removal of magnesium is very expensive, so the removal of magnesium ions in water is generally considered when the content of magnesium ions exceeds 40mg/L as calcium carbonate.

In Felindre, According to the background of assignment, the quality of water is deteriorated from original sources. The hardness of the water exceeds 200 mg/L as CaCO_3 which is more than 180 mg/L. Lime and Soda ash can be added in raw water to reduce hardness. The concentration of calcium ions in freshwater is found in a range of 0-100 mg/L. A level of 50 mg/L is recommended as the upper limit for drinking water. Levels above 50 mg/L can be problematic due to formation of excess calcium carbonate deposits in plumbing or in decreased cleansing action of soaps. After softening, the water will have high pH and excess Lime. Adding carbon dioxide to the system which reacts with excess substances to stabilize water is defined as recarbonation. Recarbonation is the most common process used to reduce pH. The treatment of hardness reduction needs to be set before Coagulation so that the precipitates can be removed by traditional coagulation and filtration processes, which not only effectively reduces the hardness of water, but also will not bring great influence to the subsequent treatment process.

4.2 Toxic heavy metals and other non-degradable substances

Heavy metal ions in water mainly come from mineral processing, smelting, electroplating and other fields. Heavy metals have high toxicity, non-biodegradability, biological enrichment and metabolic features. If people drink the water which contains even trace heavy metal ions of water, it can also lead to heavy metal enrichment in the human body. Therefore, prevention and control of water heavy metal pollution is one of the important factors to ensure human health. Generally speaking, the water sources of waterworks do not contain heavy metals, but this can also happen if there are special circumstances, such as raw water flowing through mines, being polluted and so on.

The traditional methods of treating heavy metals in water include chemical precipitation, electrochemistry, adsorption and membrane separation. The process of chemical precipitation is mature, and the purpose of removing heavy metals can be achieved by adding chemical agents to water to form precipitation. Common precipitants are lime, sodium carbonate and sodium hydroxide. Electrochemical method refers to the method by which heavy metals in wastewater are enriched by electrolysis through

redox reaction on the anode and cathode respectively. The adsorption methods include physical adsorption and chemical adsorption. Physical adsorption mainly uses porous adsorption materials with large specific surface area to adsorb heavy metals, such as activated carbon, minerals and molecular sieves. In recent years, the adsorption capacity of mineral materials has been gradually discovered. Zeolite is the mineral with the largest specific surface area and the strongest adsorption among the natural minerals found so far. Resins can chelate with heavy metal ions, forming a network of molecules that can effectively adsorb heavy metals. Chitosan and its derivatives are ideal materials for treating heavy metal wastewater. Membrane separation technology uses a special semi-permeable membrane. It is capable of separating or concentrating the solvent and solute under the action of external pressure without changing the chemical form in the solution (Yanan Zhang, 2015).

The process of chemical precipitation is applicable to a wide range, high efficiency, economic and simple. But the amount of precipitants is large. It also needs to set up precipitation separation that is easy to introduce new pollutants, causing secondary pollution. Electrochemical method is complex and is not suitable for water treatment. Since the physical adsorption process is simple to operate and does not produce secondary pollution, it is feasible to set up another adsorption plant for toxic metal removal. The adsorbent can be zeolite and chitosan. The plant can be set in front of the GAC. When the heavy metal in the raw water is not exceeding the standard, it will not be adsorbed by zeolite and chitosan; When the heavy metal exceeds the standard, it will be adsorbed by zeolite and chitosan first, and then sent to the GAC for the following treatment. Membrane separation is not suitable for large-scale processing, therefore is not suitable for water treatment in Felindre.

Non-degradable substances are usually substances that are difficult to degrade by biological action in natural conditions. They are characterized by environmental persistence and wide dispersion. At present, the main treatment methods for non-degradable substances include biological method, chemical, Physicochemical method, oxidation and combined treatment methods. These principles are similar to those of heavy metal removal, and the physicochemical methods include adsorption, extraction and various membrane treatment techniques. Non-degradable substances can be removed together with Toxic heavy metals by adsorption (Li, 2018).

4.3 Membrane filtration

Membrane filtration technology refers to the membrane separation technology with pressure as the driving force. It belongs to pressure filtration and is one of the filtration methods except gravity filtration. According to the membrane selectivity, it can be divided into reverse osmosis (RO), nanofiltration (NF), ultrafiltration (UF) and microfiltration (MF).

MF which is a screening process, is a kind of precision filtration and suitable for municipal sewage treatment and pre-treatment of wastewater treatment. Ultrafiltration membrane (UF) is a membrane process between microfiltration and nanofiltration. It uses the screening principle to separate, concentrate and purify macromolecular materials and small molecules. It is between ultrafiltration and reverse osmosis, especially suitable for concentration and desalination of low molecular weight materials. Reverse osmosis separation technology is an advanced water treatment and desalination technology. Reverse osmosis membrane separation technology is to use the principle of reverse osmosis membrane separation. it is mainly used in the preparation of pharmaceutical water, purified water and the concentration of thermal sensitive substances (Baidubaike , 2018).

In Felindre, they adopt the rapid gravity filter. Gravity filtration is dependent on the action of gravity, which requires a long time and is not efficient and cannot completely guarantee the high water quality. While Reverse osmosis membrane filtration is carried out with the pressure difference between the two sides of the membrane as the driving force, which is efficient and can ensure the quality of effluent water.

5 Conclusions

From what has been discussed above, we can draw the following conclusions:

- 1、 The whole process in Felindre water treatment includes solidification, flotation, filtration, adsorption, secondary filtration, disinfection, storage in the reservoir, and finally distribution to the users. There is no doubt that the process is reasonable and efficient
- 2、 To solve the hardness problem: By chemical precipitation, lime and Soda ash are added to the water to react with calcium and magnesium, the main ions in the water that cause hardness problems, to form precipitates, which are then removed by filtration. This process can be arranged in front of the coagulation in the original process, so that it can be removed by flotation in COCODAFF.
- 3、 To remove the toxic heavy metal and non-degraded substances: Physical adsorption is selected in many methods to remove toxic heavy metals and non-degradable substances, mainly because it will not bring secondary pollution and the process is simple and easy to operate. The adsorbents are zeolite and chitosan which are effective in removing heavy metals.
- 4、 To improve process and ensure water quality: Reverse osmosis membrane filtration can be used to replace rapid gravity filtration. Rapid gravity filtration is based on the effect of gravity. The filtration time is long and the efficiency is low. Membrane filtration is based on the pressure difference between the two sides of the membrane. It has good filtration effect, high efficiency, good effluent quality and high economic benefit for large-scale treatment.

Based on all the above considerations, a new layout diagram can be obtained.

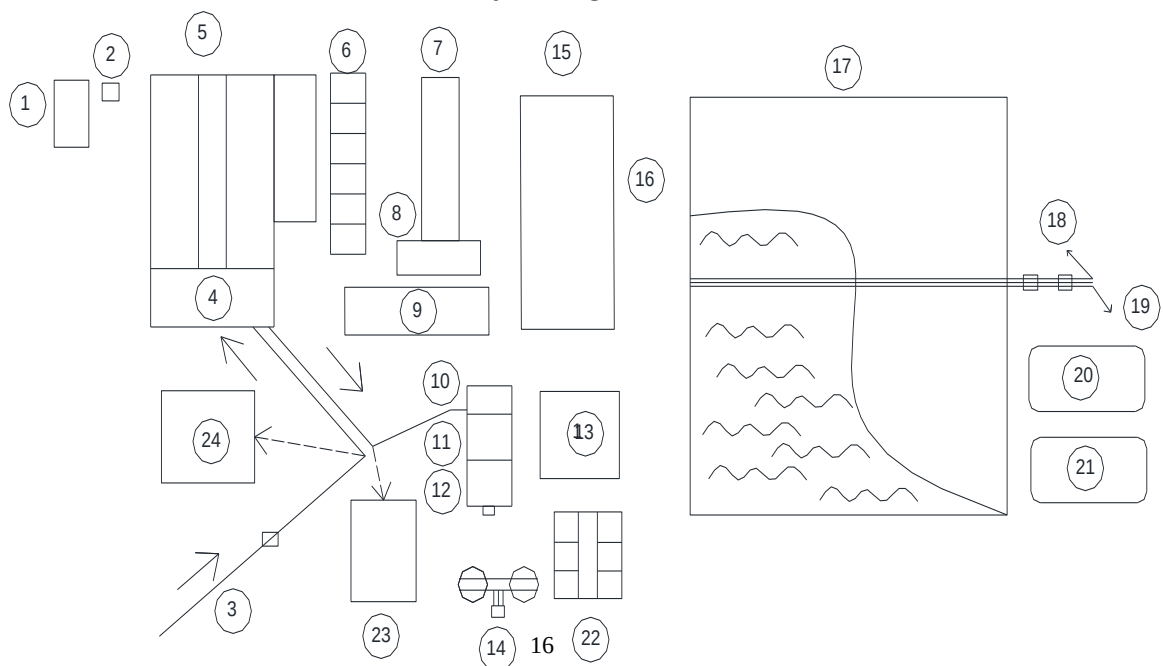


Figure 2 the modified layout of the whole Felindre water treatment plant

What is different from the previous one is to replace the 15 rapid gravity filtration with membrane filtration, adding 23 to reduce the hardness and 24 to remove toxic heavy metals and non-degradable substances. The line of water entering these two plants is a dotted line, which represents the Plant that is not necessary to enter. When the hardness and heavy metal content of water are not exceeding the standard, the water cannot be processed in these two plants, so that the processing cost can be saved.

6 References

- Felindretreatment plantwater. (2018). General introduction of Felindre water treatment plant.
- Anu Matilainen, Mika Sillanpää, Mikko. (2010). Natural organic matter removal by coagulation during water treatment: A review. *Advances in Colloid and Interface Science*, 189-197.
- Shen Zhang, Yonglei Wang, Heng Liang, Kefeng. (2019). Application of COCODAFF in treatment of micro-polluted water source. *Water purification technology*, 20-23.
- Wang LK, EM, Wu ZFahey. (2005). Dissolved air flotation. In: Wang LK, Hung YT, Shammas NK (eds.) *Physicochemical treatment processes*. Humana Press, Inc., Totowa, NJ, pp, 431-500.
- Baidubaike. (2018). <https://baike.baidu.com/item/%E8%BF%87%E6%BB%A4/8737022?fr=aladdin>.
- Baidubaike. (2018). <https://baike.baidu.com/item/%E5%8F%8D%E5%86%B2%E6%B4%97/7676241?fr=aladdin>.
- Yang Zhang, Tao, Long Yu, Jing Pan, Siyuan. (2008). Study on the treatment of micro-polluted water by granular activated carbon. *Journal of shenyang normal university (natural science edition)*, 463-465.
- Baidubaike. (2019). <https://baike.baidu.com/item/%E6%B4%BB%E6%80%A7%E7%82%AD/2628325?fr=aladdin>.
- Douding. (2016). <https://www.docin.com/p-1423174593.html>.
- Baidubaike. (2017). <https://baike.baidu.com/item/%E6%B4%BB%E6%80%A7%E7%82%AD%E5%86%8D%E7%94%9F/11004791>.
- Baidubaike. (2018). <https://baike.baidu.com/item/%E6%B0%B4%E8%B4%A8%E7%A1%AC%E5%BA%A6/22196588>.
- McGowan W (2000) *Water processing: residential, commercial, light-industrial*, 3rd ed. Lisle, IL, Water Quality Association.
- Wu Jianwei. (2018). Study on hardness characteristics and purification countermeasures of tap water. *Technology and market*, 139-140.
- Yanan Zhang, Luo, Haihong Wu, Ronghua Cai, Xiping Huang, Bijun. (2015). Research progress of heavy metal removal methods. *Salt and chemicals*, 1-6.
- Li Jinfeng. (2018). Treatment technology of refractory organic matter in industrial wastewater. *Chemical management*, 130.

Baidubaike(2018).<https://baike.baidu.com/item/%E8%86%9C%E8%BF%87%E6%BB%A4%E6%8A%80%E6%9C%AF/784930>.