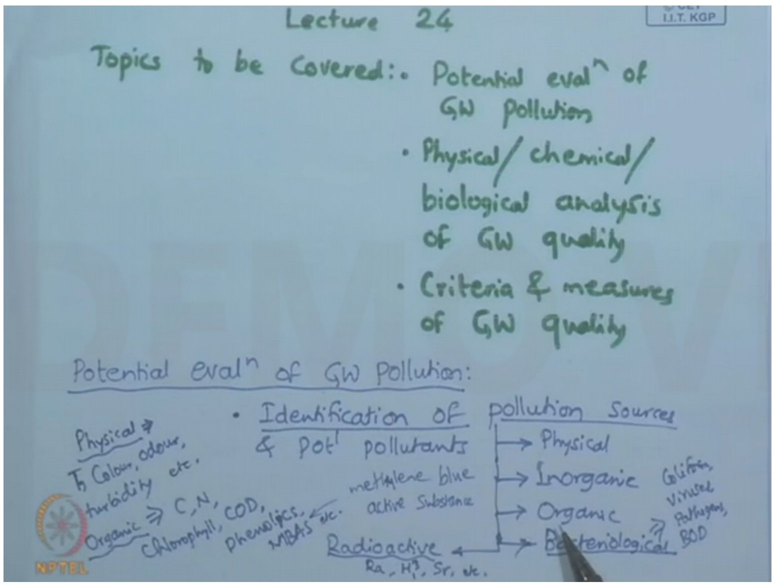
Ground Water Hydrology
Prof. DR. V.R. Desai
Department of Civil Engineering
Indian Institute of Technology – Kharaghpur

Module No # 05
Lecture No # 24
Potential Evaluation of Ground Water Pollution; Physical/Chemical /Biological Analysis of Ground Water Quality; Criteria and Measures of Ground Water Quality

Welcome to this lecture number 24 and ground water hydrology.

(Refer Slide Time: 00:26)



And in today lecture the topics to be covered are the potential value evaluation of ground water pollution followed by physical chemical biological analysis of ground water quality followed by criteria measures of ground water quality. Now let us go to this potential evaluations of this ground water pollution.

So whenever we need to evaluate the potential of a ground water pollution so this few things are essential there the first one is the identification of the pollution sources and the potential pollutants put it in a potential of these pollutants. So when we talk of this identification of pollution sources whether these are these pollute pollution sources are they coming from the landfill or are they coming from that is the water supply or are they coming from say some other sources like industrial pollution or municipal agricultural.

So they need to be taken into consideration and here so the pollutants the may be they may be either physical pollutants they may be inorganic pollutants there may be organic pollutants there may be bacteriological pollutants or there may be radioactive pollutants when it comes to the physical pollutants of the ground water pollution so here you can say this is temperature color odor turbidity etc.

So these are all can be grouped under the physical pollutants so next coming to the inorganic pollutants so here we will get the that is the heavy metals and various other inorganic there is ions as well an radicals coming to this organic pollutants. So here in this organic pollutants we have carbon nitrogen chlorophyll chemical oxygen demand as phenolic compounds which are known as phenolics and water popularly known as MBAS which stands for methylene blue active substances.

So these are all the categorized under these organic pollutants next we need to account for the bacteriological pollutants so which include the coli form bacteria the viruses the pathogens pathogenic bacteria and ten lastly the biochemical oxygen demand so these all are grouped under the bacteriological pollutants and last but not the least. So there is there are what are known as the radioactive pollutants in which three TM is there which is an isotope of hydrogen.

Then radium strontium and other radioactive materials .So here so we need to identify these sources these are the in terms of their category in whether they are originating from landfill or whether they are originating from many industrial source or whether if they are originating from municipal source or agricultural source and accordingly we need to take the future is one and next what is required is the assessment of the ground water usage.

So depending upon the usage of groundwater we need to that is we need to estimate the potential of pollutants say for example when we talk of the ground water usage so here we need to consider what are the future locations for pumping as well as extraction as so the what are the future locations of say the habitation and so on.

So where there is a possibility of more water demand and then so there is a possibility of groundwater not meeting the quality standards and causing pollution and so on and after this we also need to access the hydro geological conditions. So in this so we need to consider the act refers the depth the areal extent and other details as well as the hydraulic conductivity and so on as well as the natural groundwater recharge an discharge areas the ISO bath maps.

So all these hydrological hydro geological conditions need to be assessed properly so that we can get a fair estimate of the potential pollutants put in the evaluation the potential evaluation of the ground water pollution and last but not the least so the evaluation of the pollution mechanism so whenever there is a pollution taking place. So it takes place through the vadose zone.

So that is the basically the unsaturated zone and here the properties of the weight of zone as well as such as the hydraulic conductivity degree saturation as well as the connectivity of aquifer all these things need to be accounted for in the evaluation of this one. So once we have the information about all these fag all these items such as the identification of the pollution sources and potential pollutants assessment of the usage of groundwater.

Assessment of the hydro geological conditions as well as the evaluation of the pollution mechanism so then we will be in a position to reasonably make a good estimate of the potential evaluation of ground water pollution so now let us move over to the physical evaluation of ground water quality and this is taken from the source of the in Johnson's Johnson division from the year 1965.

And here the physical parameters of which constitutes the physical evaluation of groundwater quality include temperature electric conductivity then the total suspended solids in the total dissolved solids and here so the temperature for the normal groundwater the temperature ranges from say 10 degree, 20 degree Celsius and of course it may vary also because these are just normal ranges and there are always one.

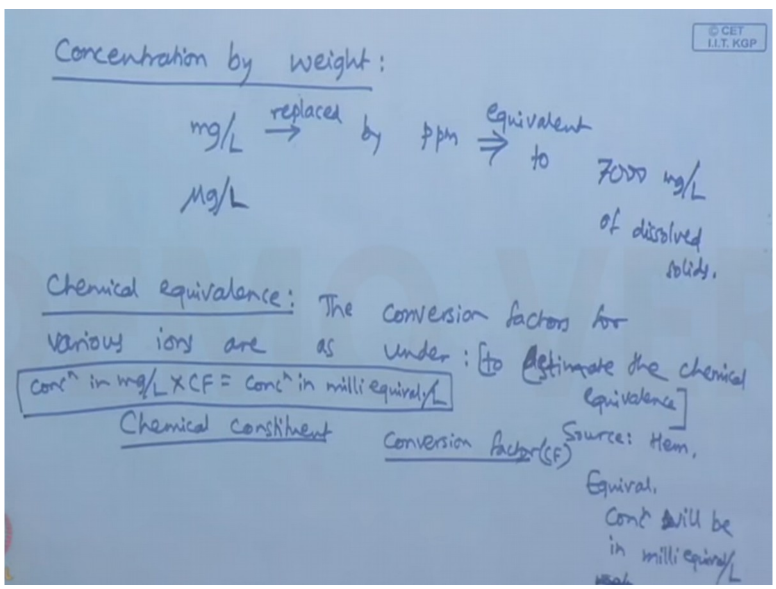
And likewise the electrical conductivity of the normal the normal range of variation of electrical conductivity is from 100 to 1000 mill moles per centimeter and coming to this other parameters such as the total dissolved solids so the normal range varies from 100 to 500 PPM and of course in this case. So if they so there may also be regions where the total dissolved solids concentration may go even below hundred or may go even above five hundred.

Depending upon the hydraulic conductivity and likewise the total suspended solids concentration also normally where is in the range of say 100 PPM to 500 PPM and of course it can also depending upon the various locations as well as various special specific cases it may even go below hundred or may even exceed 500 and then so this turbidity also one of the parameters.

So in which we can say the normal range of the ground water turbidity is from one to five which is very much within the permissible range and so likewise so if the evaluation of all these physical parameters constitute what is known as the physical evaluation of ground water quality now we will go to the chemical analysis of this ground water quality here in the chemical analysis of groundwater quality.

So the parameters which are analyzed which are analyzed are that is the concentration by weight followed by chemical equivalence followed by total dissolve solids by electrical conductance then the hardness. So these are the chemical analysis these constitute the chemical analysis of the ground water and first let us see the concentration by weight.

(Refer Slide Time: 11:26)

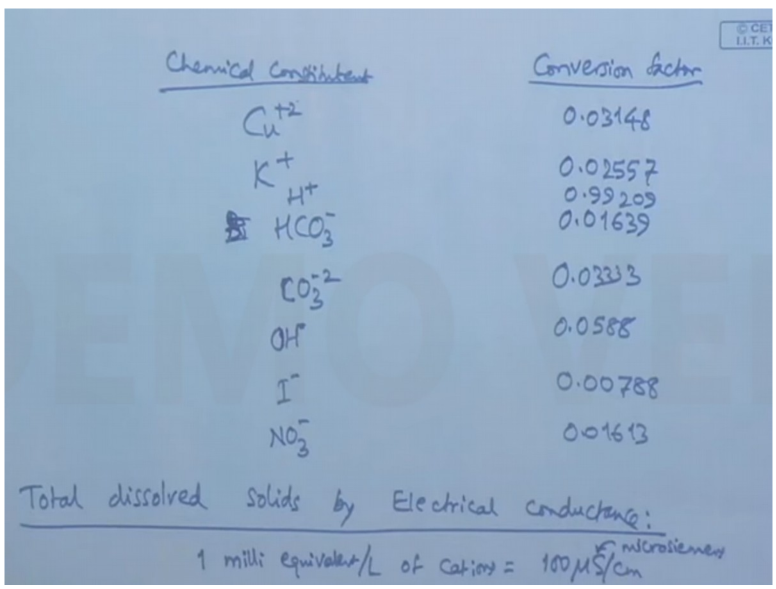


So in this concentration by weight so here so this case this milligram per liter so this is replaced by parts per million and this one so this is the ionic concentration or sometimes so it is also express in terms say microgram per liter and this one it is said that the milligram per le the milligram per liter. So this milligram per liter is equivalent to say 7000 milligram per liter of dissolved solids and next we will come to the chemical equivalence.

So in this the various ions the conversion factors for various ions are as under so here so this is to determine or say to estimate the chemical equivalence here so this is the source is from hem and in this the chemical constituent and then the conversion factor once you multiply this conversion factor so it will the equivalent concentration. So will be in terms of in milli equal lent per liter. so if the concentration.

So basically that is concentration in mg per liter multiplied by this conversion factor CF so that is a concentration in MG per liter multiplied this conversion factor CF. So multiplied CF which is equal to concentration in milli equal lent per liter so this is the equation and here let us consider some of these say the aluminum ion AL + 3. So it has a conversion factor of say .1119 likewise the ammonium that is NH 4 +. So it has a concentration of a .00544 and among them.

(Refer Slide Time: 18:11)

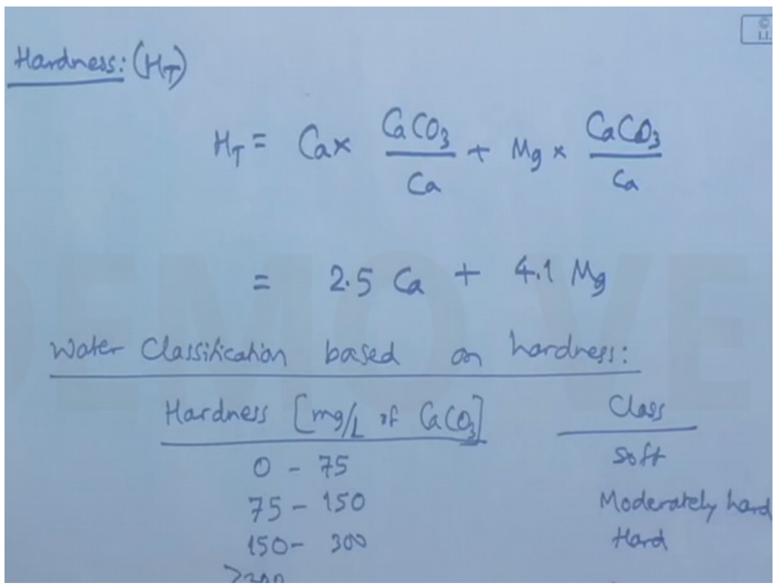


So these are for some of the cautions like so some more can be listed here like that is the barium. So BA + 2 so it has a conversion factor of .01456 and let us go to some of the cautions so the chemical constituent then conversion factor like say here this copper so copper b has a conversion factor of .03148 this potassium say K + it has a conversion factor of 0.02557.

Now let us come to some of the anions and here in this anions so this bicarbonate that is a HCO three so it has a conversion factor of say .01639 and then carbonate CO 3 - 2 so it has a conversion factor of .03333 likewise this hydroxide that is OH minus it has a conversion factor of .0588 and here among the cautions the highest conversion is a factor is for the hydrogen ions.

So for the hydrogen ions the conversion factor is as high as .99209 likewise among the cautions the least conversion factor is for iodide so that is .00788 and then this nitrate NO - 3 it has a conversion factor of a .01613 so this is regarding the this one the chemical equalance and now we will go to the this total dissolve solids by electrical conductance so here this 1 milli equivalent per liter of cautions is equal to 100 micro that is Siemens.

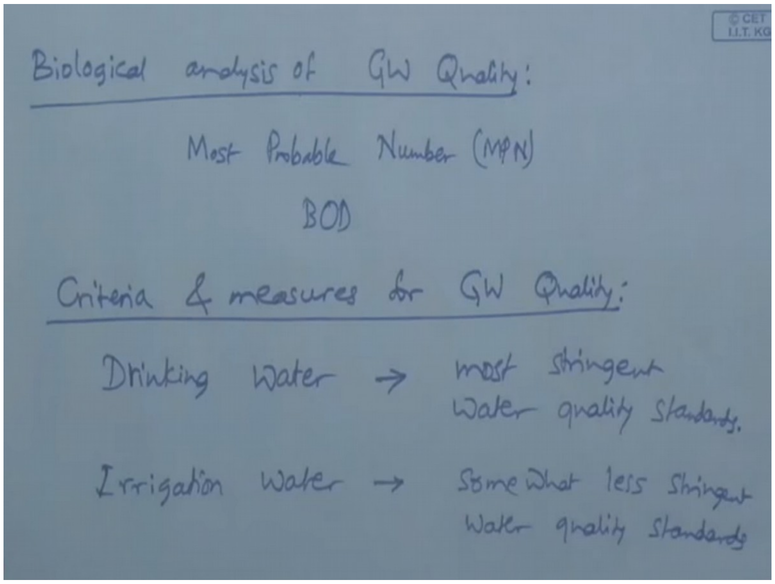
(Refer Slide Time: 22:23)



So this is micro Siemens per centimeter so this is the conversion for total dissolved solids in terms of electrical conductance and the lastly we will come to this is a the hardness so this hardness which is abbreviated as HT so we can expressed as calcium and magnesium hardness and this HT which is equal to calcium multiplied by this calcium carbonate plus magnesium harness that is also multiplied by calcium carbonate.

Calcium and so if this is equal to say 2.5 the calcium hardness + 4.1 time the magnesium hardness so that will give the total hardness and of course so here the some this one that is so the classification based on hardness that is water classification based on hardness is say here this hardness in milligram per liter of CACO 3 and the class are if the hardness is between 0 and 75 milligram per liter then it is called a soft water.

(Refer Slide Time: 24:59)



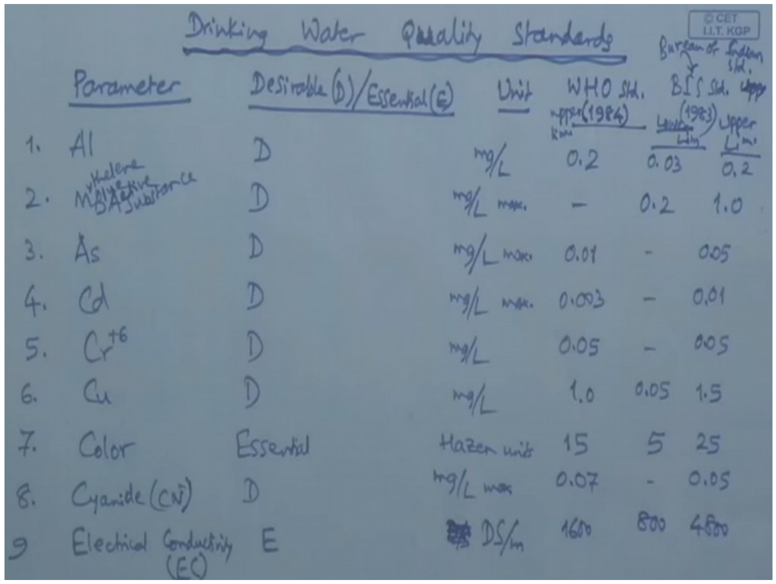
If it is 75 to 150 it is called moderately hard so 150 to 300 it is called hard 300 above 300 nit is very hard so this is how the water is classified based on the hardness next this coming to this biological analysis of ground water quality so here we know that so this so there is what is called the NPN the most probable number to quantify the micro-organisms and also what is called to is this BOD so these are to a biochemical oxygen demand.

So these are these indicate the two of major parameters based on which the biological analysis of ground water can be done and so accordingly you can classify the ground water as this good or acceptable or that is requiring treatment and so on now let us come to the criteria that is criteria and measures for ground water quality. So here we should know that the depending upon the purpose for which the ground water is used.

So the criteria of the ground water quality has to be decided and we all know that so this drinking water requires the highest quality of ground water highest water quality so therefore this drinking water has most stringent this one so that is a say drinking water most stringent water quality standards so next below this is the irrigation water that is somewhat less that is less stringent water quality then other purposes.

So it may be the water quality standards may even be less say if it is used for maybe other purposes other than drinking or irrigation so wherein in so it is one.

(Refer Slide Time: 29:03)



So now let us consider this the drinking water quality. So the drinking water quality standards so here let us list the parameters then whether their desirable or if it is desirable let us write as D or if it is essential let us write it as E then the unit in which that is the parameter is quantified then the world health organization standards WHO standards as per say 1984 of coarse then have been revised sometime in the late 2000 and then this bureau of Indian standards BIS standards.

So this is the bureau of Indian standards so this is also nineteen eighty three then this upper limit so here in this let me also write this upper limit so now firstly let us consider that is the AL aluminum so it is desirable it is not essential and units are milli gram per liter and as per the WHO standards is the .2 milli gram per liter and as per the this one bureau of Indian standards. So the minimum is so this is lower limit is 0.03 and upper limit is 0.2.

Next is the MBAS that is methylene blue active substance so this is also desirable and this is unit is MG per liter max and it does this WHO does not have a standard whereas as per bureau of Indian standards it has to it needs to within .2 and 1 next is arsenic which is toxic substance of course however that is also in this 1 and this a it is also been listed as desirable and this mg per liter maximum.

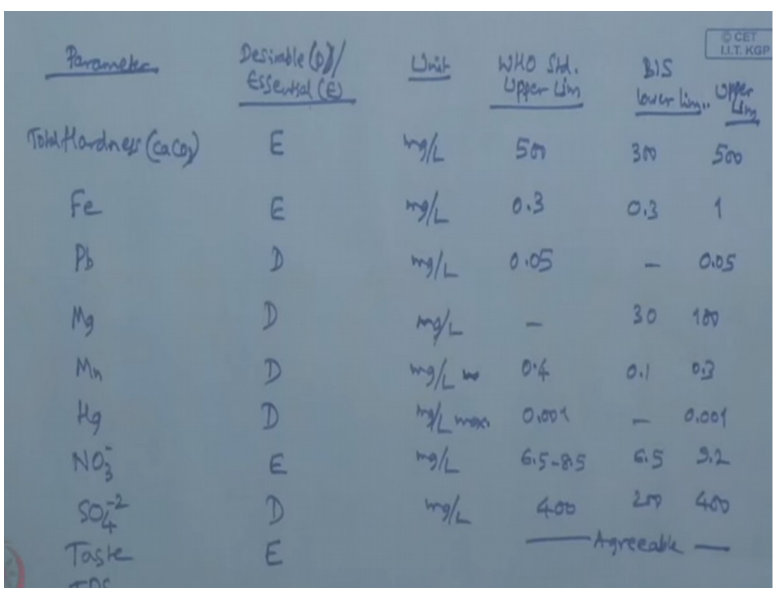
So again this arsenic even the maximum concentration should not exceed .01 milligram per liter and so here so this is .05 milli gram per liter that is upper limit next is cadmium the cadmium is also desirable mg per liter max it is .003 and here so this is .01 next that is so this is the chromium CR + 6 so it is also desirable and so this mg per liter and chromium needs to be within .05 and it is the same as person next is copper.

So this copper is also desirable and so again the units are same mg per liter and it is the maximum is a one as per world health standards. So this is world health and this is standard upper limit obviously and in this in case first one it has to be the minimum is .05 and maximum is 1.5 next is this color .So color is it is essential and so it is expressed in terms of hazern units and it is the upper limit as per WHO standards is 15 and as per the bureau of Indian standards.

It needs between 5 and 25 next is cyanide that is CN minus and this is also a toxic substance that is however it is also that is desirable and it is this one cyanide is mg per liter max and it needs to . 0 within .07 and so here as per the bureau of Indian standards it has to be within .05. So next is the electrical conductivity that is EC so this electrical conductivity is essential it is the unit is DS per meter that is decimal per meter.

Deci Siemens per meter then it is 1600 the upper limit and as per the bureau of Indian standards it needs to be between 800 and 4800 so next we will so these are some of the parameters.

(Refer Slide Time: 37:49)



Parameter	Desirable (D)/ Essential (E)	Unit	WHO Std. Upper Lim	BIS lower Lim.	Upper Lim
Total Hardness ($CaCO_3$)	E	mg/L	500	300	500
Fe	E	mg/L	0.3	0.3	1
Pb	D	mg/L	0.05	–	0.05
Mg	D	mg/L	–	30	100
Mn	D	mg/L w	0.4	0.1	0.3
Hg	D	mg/L max	0.001	–	0.001
NO_3^-	E	mg/L	6.5-8.5	6.5	9.2
SO_4^{-2}	D	mg/L	400	200	400
Taste	E		— Agreeable —		

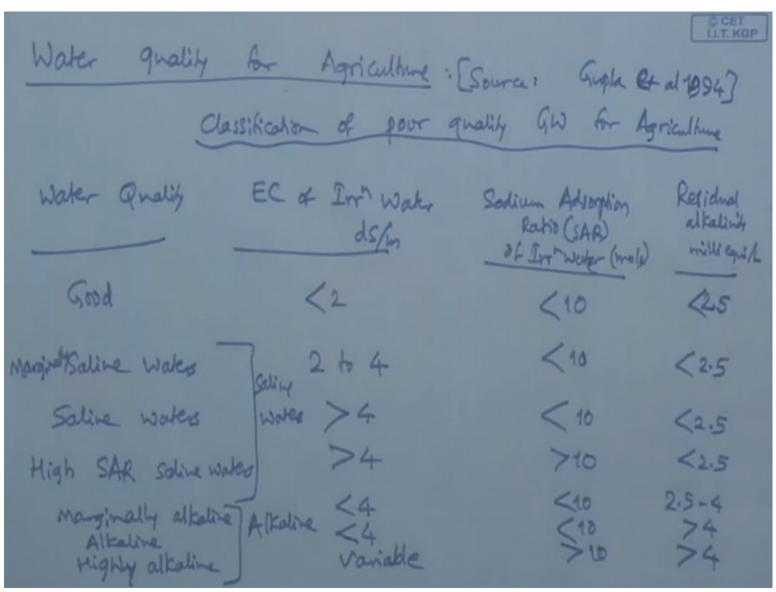
So let me list the parameter then whether it is desirable that is D or essential E then the unit then WHO standard upper limit and bureau of Indian standards that is lower limit upper limit .So we will go to this hardness as the total hardness as CACO 3 in terms of CACO 3. So this is essential and it has units of mg per liter and it is the upper limit or as per WHO standards is 500 as per Indian standards.

So 300 to 500 and next is higher so it is essential so the same mg per liter .3 and here it is bureau of Indian standards 0.321 next is lead. So this is desirable so this is mg per liter .05 and here also it is .05 as per the upper standards upper limits of this next is magnesium it is also desirable the so WHO as per this is also mg per liter and here it is not given.

So whereas as per the bureau of Indian standards it is nineteen eight three it is between 30 and 100 and then next we will go to manganese it is desirable so mg per liter max mg per liter and so this is .4 and in this case in case of bureau of Indian standards it is .1 and .3 next is mercury it is also considered poisonous but however it is list and here this is mg per liter max and this 1.001 and here this is the same next is this nitrate.

So it is essential then 6.5 to 8.5 mg per liter 6.5 to 8.5 and here it is a 6.5 and then 9.2 now this sulfate so this sulfate is desirable mg per liter so it is 400 is upper limit and then 200 as per this one 200 to 400 next is like taste so taste is essential and here it is sorry this one so everywhere it is written as say it has to be agreeable next is this TDS total dissolved solids.

(Refer Slide Time: 43:01)



So this is mg per liter max this is desirable mg per liter max and this has to be upper limit is thousand and it has in this case it is 200 to 2000 as per the bureau of Indian standards so these are some of the standards and now let us discuss the so this water quality for agriculture so here so this the classification of poor quality ground waters for agriculture so this is source it is GUPTA at all that is 1994.

So in this classification of poor quality ground waters so this is the water quality then the EC of irrigation water which can be used for irrigation or agricultural water so in terms of deca seaman per meter next is this sodium absorption ratio that is SAR in terms of irrigation water in terms of mole next is this residual alkalinity. So this residual alkalinity so this residual alkalinity in milli equivalent per liter.

So here so if the water quality has to be good then this electrical conductivity for irrigation water it has to be less than 2 deci Simon per meter and the sodium absorption SAR sodium absorption ratio has to be less than 10 now the residual alkalinity has to be less than 2.5 milli equivalent per liter so next is if these saline waters.

So they have an electrical conductivity ranging from say 2 to 4 and again the sodium absorption ratio is less than 10 and this residual alkalinity is again less than 2.5 so this is marginally saline waters next is saline water so this saline waters the electrical conductivity for of irrigation water is greater than 4 then this however the sodium absorption ratio is still less than 10 and the residual alkalinity is still less than 2.5.

Next is high sodium absorption ratio and saline waters in this case the electrical conductivity is greater than 4 and this 1 is greater than 10 and this is less than 2.5 so these are all these three come under saline waters now coming to this alkaline waters so that is a marginally alkaline for this the electrical conductivity is less than fore this SAR is less than ten and then this residual alkalinity is say 2.52 for next is alkaline.

So there for then the electrical conductivity is less than 4 the SAR sodium absorption ratio is less than 10 and residual alkalinity is greater than 4 million per liter and next is highly alkaline so all these three come under alkaline water and again this highly alkaline also this electrical conductivity is variable this sodium absorption ratio is greater than 10 and this is greater than 4.

So like this the so if the electrical conductivity is less than 2 the sodium absorption is less than 10 and the residual alkalinity is less than 2.5 milli equivalent per liter and then that is the ideal and which can be used for all kinds of agricultural crops. However if it is a either marginally saline or saline high sodium and so in that case we have to it is depending upon the crop we need to use this selenium and so this is how regarding the this one and in the next lecture we will be discussing about the other aspects of ground water quality thank you.